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DEFECTIVE FOUNDATIONS AT MT. ROYAL WATER-WORKS PUMPING STATION, BALTIMORE, MD.

By ALFRED M. QUICK,* Assoc. M. Am. Soc. C. E.

Mt. Royal Pumping Station is the largest of the three pumping stations in the Baltimore Water supply system. It supplies what is called the Western High Service district, which is principally a residence section containing about 150,000 people. It was planned for in 1896 as a part of a $2,000,000 improvement in the water supply system to provide for the maximum needs of that rapidly growing section of the city.

The station (see view, Fig. 1) comprises two buildings, an engine house and a boiler house, with a two-story flat-roofed connecting structure and a coal and ash tower in the rear of and connected to the boiler house. The foundations were built entirely of concrete up to a point about 5 ft. below the basement floor line. Above that point they are of brick masonry. The superstructure is of brick masonry, faced with white Maryland marble on the exterior, with steel roof trusses. It has side-track connections with both the Pennsylvania R. R. and the Baltimore & Ohio R. R.

The equipment of the station comprises two 17,500,000-gal. horizontal Worthington high-duty pumps; four 200-HP. National water-tube boilers, with Roney mechanical stokers; two Lundell 30-KW. dynamos driven by two Skinner engines; a Hunt conveyor system for coal and ashes, with nine 200-ton steel coal bunkers framed in with the roof of the boiler house and supported on steel beams set in the boiler house walls.

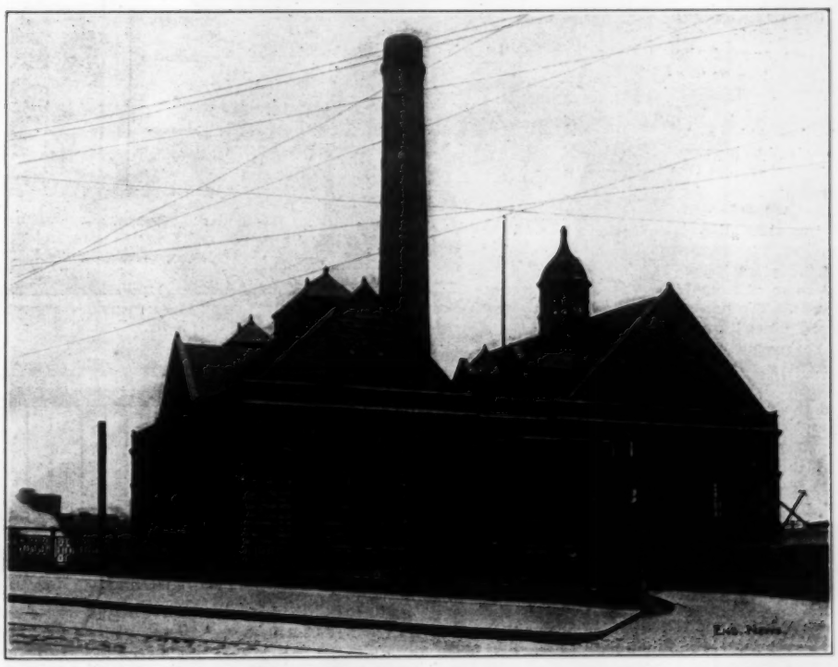

FIG. 1. VIEW OF MOUNT ROYAL PUMPING STATION, BALTIMORE WATER-WORKS.

Work on the station was begun in June, 1897, and it was completed in October, 1899, before the writer was appointed water engineer. Previous to 1900, the water department was governed by a water board, of which the water engineer was an employee. The water board engaged an architect to design the station before the lot was bought. The lot was brought to the attention of the water board by the architect, and it was purchased against the advice of the water engineer. It had once been a deep ravine in which were two natural water courses running to Jones Falls. Many years previous to the purchase of the lot two city sewers had been constructed through it to take the drainage flowing in the watercourses, and the lot had been used as a terminal by one of the old street railway companies. For some years after the car barns had been torn down the lot was used as a dumping ground, and ashes, brickbats and other refuse had been deposited there to a depth of several feet.

After the purchase of the lot, 9 or 10 wells 5 ft. in diameter were dug at various points to determine the character of the soil and the depth of the rock. The ground surface, as it then existed, was very irregular, and the wells varied from 19 to 47 ft. in depth to solid rock bottom.

The architect's contract with the water board and all contracts for construction work provided that he should have exclusive control of the construction of the station and all foundations, and also of the installation of all its equipment, except the metal work of the pumps and boilers. The architect's plans provided for sub-foundations of concrete, as shown on the accompanying plan, Fig. 2, consisting mostly of circular piers, from 5 to 10 ft. in diameter. The architect's specifications required that the excavation for each of these foundations should be made to rock bottom, and that any soft or rotten rock should be benched off to procure a good bearing surface for the concrete. They also required that the piers should be accurately located and be made plumb and regular. The specifications also required that the concrete should be made of 1 part cement, 2 parts of sand, and 5 parts of stone, with the customary provisions for mixing, depositing, building up in layers, ramming, and joining old and new work, conforming to the very best modern practice.

As previously stated, the concrete sub-foundations were brought up to a point about 5 ft. below the basement floor line, and the crib sheeting in the pier wells and the lagging in the pump and stack foundation wells were left in place. On top of these sub-foundations, completely covering the area of the entire structure, was placed a blanket of concrete 1½ ft. thick. Above this blanket all wall and bed foundations are of brick, which, not being found defective to any extent, it is not necessary to describe.

During the construction of the sub-foundations there was at one time a very heavy rain. The water rushed to the sewer inlets at the low point in the street in front of the lot in greater volume than they could carry off, and the excavations were flooded; considerable damage being done to the timber cribs, lagging, and concrete work. The contractors made a claim for compensation for this damage, which was not allowed.

As before stated, the station was completed in October, 1899, but it was not put in operation until the writer came into office in January, 1900. Within a year the first crack in the walls developed. It was in a window sill stone, in the south wall of the boiler house basement, directly over the manhole on the sewer under the boiler house shown on the plan (Fig. 2).

This sill cracked clean through. The crack was watched and measured for a long time, but got no worse. Shortly afterwards cracks began to appear in the engine house. The first one was over an archway in the north basement wall leading to the back part of the two-story connection between the engine and boiler houses. This widened gradually to about an inch, and as it widened a long irregular crack appeared in the engine room wall above it, extending clean up to the top, as shown on the accompanying view, Fig. 3. This was over six years ago. Other cracks also began to show in the engine house, two in the large Tennessee marble wainscoting slabs on the

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interior, six or eight in the white marble blocks on the outside of the south wall, and a long vertical crack at the northwest corner, where the engine room joins the porte-cochere and the front wall of the two-story connecting building. Several cracks also appeared in the outside of the back wall of this connecting building. The north wall of the engine house also moved or settled sufficiently to allow the roof joists of this connecting building to pull about an inch away from it. The northeast corner of the engine house began to settle, so that the floors there were noticeably out of level, and the wall corner itself became about 2 ins. out of plumb from the top to the ground. The floor at the northwest corner of the engine room also settled perceptibly. Two or three years ago, also, one cross-head guide casting in each of the two pumps cracked. These breaks were not positively traced to any settlement of the pump foundations, but very likely that might have been the cause.

All of these cracks and breaks caused considerable concern, of course, but as we had every reason to believe that the foundations were of solid concrete, resting on solid rock no inspection of them had been attempted. We were constantly watching and measuring these cracks, however, and some of them widened perceptibly.

Early in 1907 we began to plan for the erection of a third pump, on the vacant foundation in the engine house, and the writer considered it wise to first have a thorough examination of the building and foundations made by a competent authority. Consequently he asked the building inspector to make such an examination. From his inspection of the superstructure he pronounced the building to be in a suspicious condition, warranting a thorough examination of the foundations. Work was immediately begun with an experienced superintendent and men working under his direction. Excavations were made down around the foundations under the east walls of the engine room and of the connecting building. Startling conditions were found at once. The east wall of the connecting building had bridged itself between the engine and boiler house walls, its brick foundation had sunk away from it about 2 ins. in the center and the concrete sub-foundation had settled about 6 ins. away from the brick in the center, as shown on the accompanying view, Fig. 4. The concrete in the blanket under the engine house showed good, but that in the piers immediately below was very poor and some of it could be pulled to pieces with the hands. Temporary trestles, needles, and braces were placed under and against the east walls of the engine house, supported partly by timber columns set in wells excavated 35 to 40 ft. down to the solid rock. Pits were also excavated to about the same depth, between the pump foundations and down at one side of the stack foundation. It was evident from the conditions revealed in these test pits that all the concrete foundations would either have to be rebuilt or materially strengthened. Consequently, no further explorations were made in advance of reconstruction, but repair work was begun at once under the plans and direction of the building inspector, with men employed by him.

As the first test-excavations were being made at the east wall of the engine house and connecting building, very hot water was encountered in considerable quantity at a depth of about 18 ft. from the surface of the yard. This was first thought to be from leakage from the hot-water drainage system which had been laid, according to the architect's plans, in the earth under the concrete floor of the building without any manholes or other means of access. As the excavation advanced, however, greater volumes of hot water were encountered. We then decided that the water came from the hot well, which was built, under the architect's plans, in the yard about 20 ft. from the east wall of the engine house. This hot well is 5 ft. in diameter and about 28 ft. deep, built of brick masonry lined on the inside with a coating of neat cement 1 in. thick. The hot-water drain pipe comes in at the top and turns down to the bottom of the well, and an overflow pipe runs from the top to the sewer near by. Consequently the hot-water drain pipe was disconnected from the hot well and turned directly into the sewer temporarily. This at once stopped the hot-water leakage into the excavation. Examination of the hot well showed that the cement lining was cracked badly and broken off in places, thus accounting for the leakage. The hot water was found in such volume in the excavations under the east wall that powerful siphons had to be operated continuously to enable the work to proceed. Our curiosity was aroused as to why the hot water should have remained in the ground under the building and not run off down the slope of the underlying rock, which inclines sharply down to Jones Falls only a few hundred feet to the east of the building. Upon investigation we concluded that it must be because the two sewers (one coming from the west and the other from the south) which have previously been mentioned as being built through the lot, were down on the rock, and, joining at Jones Falls, formed a dam which retained the hot water behind it. That such was the case was shown by an inspection of the interior of the sewers made by employees of the city engineer's department, who found the walls of the sewers to be so hot that they could not keep their hands on them.

Now, as to the general condition of the concrete foundations. So far new foundations have been built only under the east walls of the connecting building, and partly under each of the four side walls of the engine house. Sixteen of the foundation piers have been exposed, 15 under the engine house and one under the boiler house at the point of junction with the east wall of the connecting building; the three pump foundations have been partly exposed on the sides, and the stack foundation has been partly exposed on its east side. Only one of all these foundations, one of the piers, was found to be entirely bedded on the solid rock. Most of the piers did not reach to within from 3 to 5 ft. of the solid rock at any point. The bottom of two or three of the piers touched a point or ridge of the solid rock, but the rest of the bed under them was either rotten rock or soft muck. On all of the pier holes, wooden cribbing had been put in to a depth of about 4 ft. from the top. Below that level the earth had apparently been considered firm enough to excavate without cribbing, and the sides of the pier hole had either partly caved in or been washed in by the flood I have previously mentioned; and the concrete had evidently been simply dumped in the hole without regard to what sort of a foundation it rested on or what form it took; so that the bottoms of some of the piers have only about half the area of cross section that their tops have. Some of the piers were out of plumb several inches, and one of them had evidently been started out of line and when about half way up abruptly set over about 10 ins. to bring it in line.

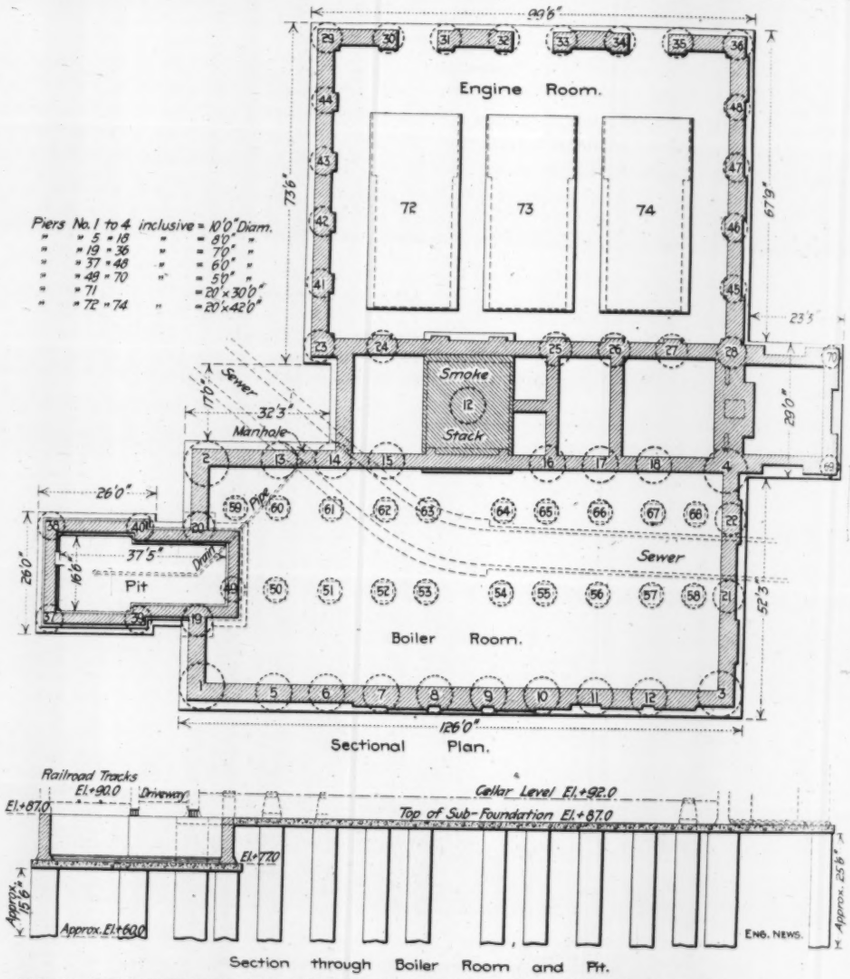

FIG. 2. FOUNDATION PLAN AND SECTION, MOUNT ROYAL PUMPING STATION, BALTIMORE WATER-WORKS.

At the bottom of all of the six piers under the east wall of the engine house was from 1 to 3 or 4 ft. of concrete that appeared pretty good, although not so hard as it should have been. All of the rest of the concrete in all of the piers was poor to a varying degree but all absolutely unfit for the purpose. The concrete in the piers under the west wall of the engine house, where no hot water was encountered, was the worst of all. Some of it could be easily picked out, some could be shoveled out, and whole piers could be pulled to pieces easily with the hands. About 8 ft. of the bottom of one of the piers sloughed off of its own weight and the whole pier was only prevented from collapsing by sheeting and shoring it.

Neither any one of the three pump foundations (see Fig. 5) nor the stack foundation, so far as exposed, rests upon solid rock or is within three

or four feet of it. The underlying material was found in one of the test wells to be muck so soft that the sides of the test pits had to be cofferdammed to prevent the stuff from squeezing or oozing out. The concrete found in these foundations is better than that in the piers but is far from being first-class concrete.

The only concrete in the whole foundation which appeared to be very good, and which was hard to break up with a pick, was that in the concrete blanket on top of the sub-foundations. This condition of affairs is a sufficient explanation, undoubtedly, in anybody's mind as to the direct cause of the settlement and cracks in the superstructure. There has been some difference of opinion, however, as to the cause of the poor concrete. It has been suggested that electrolytic action might have been a contributory cause, as the third rail of the B. & O. R. R. with its high-tension current skirts the east side of the station lot. A prominent consulting electrical engineer here, who has been making a comprehensive electrical survey of the city and suburbs for one of the large public service corporations, recently investigated the conditions around the pumping station lot with special reference to any leakage from the Baltimore & Ohio R. R. tracks to the gas pipes in the street in front of the station. Electrical inspectors in the building inspector's department also made several investigations and a series of tests in and around the station soon after the condition of the foundations was first exposed. These investigations and tests showed that there was considerable leakage from the B. & O. tracks through the earth towards the pumping station, varying in quantity and intensity according to the position of the electric locomotives with regard to the pumping station. The pumping station is about half way between Camden Station, where the B. & O. electric power house is and where the electric locomotives start, and the point where these locomotives drop the trains to return down grade to the starting point. The current leakage was found to be greatest in volume and intensity, of course, when the electric locomotives were passing the pumping station on the up-grade, hauling a train; it was greater after the locomotives passed the pumping station going up with a load than when they were approaching the pumping station on the way up from the power house; and it was least when the locomotives were running down grade to the starting point without taking current or when they were standing idle at Camden station. The observed leakage varied in intensity from 4 to 20 volts and in quantity on the test wire alone from 9 to 40 amperes. This leakage was found upon investigation to be largely due to the insufficient and defective bonding on the B. & O. tracks, a defect that I am informed is now being remedied.

Tests were made, by the electrical inspectors, from the B. & O. tracks, to the street railway tracks on the street in front of the pumping station, to the earth at the bottom of the excavation around the east foundation piers of the engine house, and to the piers themselves; also from the hot water iron drain pipe running to the hot well, to the east foundation piers and to the big water mains leading out of the station; also from the street railway tracks to these water mains; also from the earth at the bottom of the excavation around the east foundations, from the foundation piers, and from other points in the station, to the water mains. Unfortunately, these tests were not made simultaneously, so that on account of the great variation in the amount and intensity of the current leakage which I have mentioned the relative potentials of all these points and materials under exactly the same conditions was not determined. However, the tests made showed: that the B. & O. tracks were positive to the street railway tracks by from 4 to 20 volts, and positive to the east foundation piers by from 0.4 to 14 volts; that the hot-water drain pipe was positive to the east foundation piers by from 3 to 12 volts and to the big water mains leading out of the station by from 3 to 18½ volts; that the street railway tracks were positive to the water mains mentioned by from 0.7 to 2.3 volts; that the foundation piers were positive to the water mains by from 0.2 to 0.9 volt; and that the earth at the bottom of the excavation around these piers was positive to the water mains by from 0.3 to 2 volts.

While the quantity and intensity of this electric current leakage is shown by these figures to be very great, a careful inspection of all metal work, pipes and machinery in the engine house failed to reveal any damage except at the joints of some 1½-in. steam-heating pipes and at several points on the iron hot-water drain which was laid between the basement floor and the concrete blanket 5 ft. below; the pitting and erosion of the latter being considerable. As to whether electrolytic action, even with currents of the quantity and intensity indicated by the tests, could materially affect the concrete piers, under the conditions existing at the pumping station, as shown, with no metal work in or around those

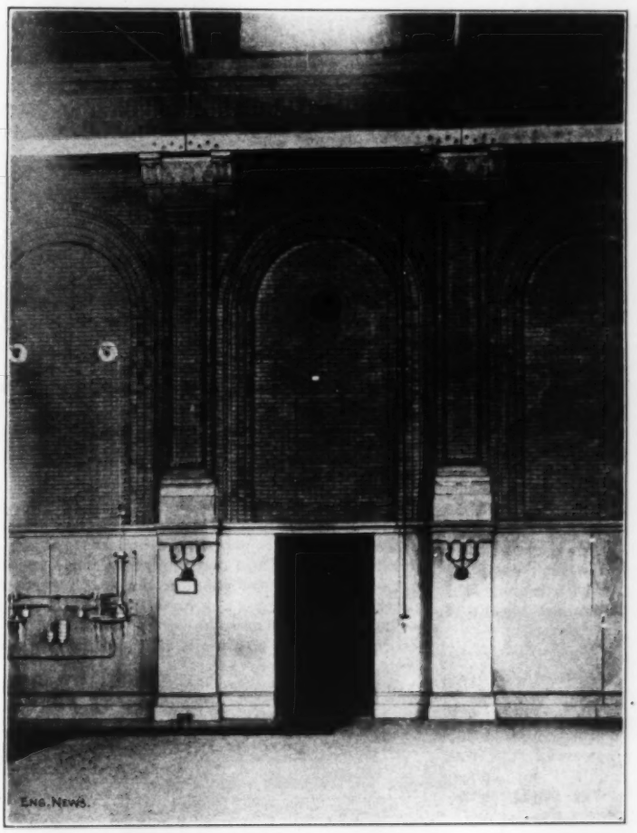

FIG. 3. VIEW OF CRACK IN ENGINE ROOM WALL, MOUNT ROYAL PUMPING STATION.

piers below the concrete blanket, I am not prepared to say. While experiments have been made, under laboratory conditions on a small scale, to determine the effect of a strong electric current on concrete immersed in water with iron imbedded in it, which tended to show that considerable damage could be done to concrete under those conditions, I know of no experiments having been made to show the effect of electric current on concrete in large mass, underground, with no iron imbedded in it or nearer to it than was the case at the pumping station. Consequently, I cannot reason from actual experiment or demonstration that the electric current could or could not have affected the piers. Even a critical examination of the concrete piers could not determine that point. It would naturally be supposed that if the piers were affected to any extent by electrolytic action it would be only on their exterior surfaces. In most of the piers the concrete was apparently just as bad on the interior as on the exterior surface, and in cases where the exterior showed somewhat worse than the interior this could just as reasonably have been due to the ashes which were found in the exterior concrete at some of those points, or to the fact that, although the specifications required that the ribs in the well cribbing for the pier holes should be removed as the concrete was put in, none of these ribs were removed, and they may have acted to retain the stones and other coarser material in the concrete at the outer surface of the piers. It would seem reasonable to suppose that if electrolytic action was affecting the piers it should have acted on the concrete at the bottom of the east piers and on the concrete in the blanket, all of which was as much exposed to the stray electric current as were the poor parts of the east piers and more exposed than the poorest piers on the west side of the station, yet which was found to be hard concrete showing no signs of disintegration.

It has also been claimed that the bad condition of the concrete in the foundations was caused by the hot water. There was nothing in the appearance of the concrete in place that indicated any possible damage from this source. As I have stated in relation to possible electrolytic damage, the concrete in the center of the piers appeared about the same as that on the exterior surface. Also the concrete in the west piers, where no hot water was found, appeared much worse than that in the east piers, where the hot-water conditions were the worst. Also the concrete at the bottom of the east piers which must have been submerged in the hot water for the longest period appeared almost as good as that in the blanket which was not touched by the hot water. Also, excepting the foot or two of good concrete at the bottom of the east piers, there was no apparent difference in the rest of the concrete in those piers above and below the hot-water level.

In order to be more certain as to this point, however, samples were taken of the concrete in one of those piers at two points, one well above and the other well below the hot-water level, and these samples were sent to the best testing laboratory in the city for analysis. The composition of the two samples of concrete as shown by this analysis is as follows:

	Percentage Compositions of Concrete.	
	Below hot-water level.	Above hot-water level.
Cement	3.60	0.53
Builder's lime	2.80	5.39
Stone and gravel	72.60	72.80
Sand	15.32	11.35
Silt	4.76	8.56
Material dissolved other than cement	0.92	1.37

The action of the hot water on the concrete would probably tend to dissolve the lime and wash out the silt. It will be observed that the sample from below the hot-water level shows less lime and less silt than the one from above the hot-water level. This might have been due to some action of the hot water, or it might with equal probability have been a difference existing in the original mixture, for regarding the builder's lime as a part of the binder the two samples of concrete would show a mixture of about the same proportions as follows:

	Concrete, below hot-water level. (parts.)	Concrete, above hot-water level. (parts.)
Binder	1	1
Sand and silt	3.3	3.6
Stone and gravel	11.3	12.3

Regardless of the extent to which electrolysis and hot water may have affected the concrete, there certainly were enough evidences of defective construction and failure to comply with specifications in other particulars to warrant the suspicion that there might be other causes for the poor concrete than those two extraneous forces. Consequently, in pursuance of this suspicion I made a thorough investigation as to the kind of cement used and its strength, as to the quality of sand and stone used, and as to the proportion of each of these ingredients existing in the concrete.

The contractor for the sub-foundations bid and was paid a lump sum of $21,985 for the concrete blanket and for an assumed average depth of piers and beds of 25½ ft. below the concrete blanket, aggregating in quantity about 6,000 cu. yds. He also bid $3.24 per cu. yd. for extra concrete in foundations and was paid for 671 cu. yds. at that rate. The cement specified to be used for all concrete work was either one or the other of two brands of a domestic natural rock cement, one designated "Natural" and the other "Hydraulic," both of which were frequently used in this vicinity at that time.

FIG. 4. SETTLEMENT OF CONCRETE SUB-FOUNDATION AND OF BRICK WALL ABOVE IT, MOUNT ROYAL PUMPING STATION.

I have not been able to find out positively, for various reasons, as to which one of these two brands of cement was most used in the pumping station foundations, but, from such information as I have been able to obtain, it is probable that the "Natural" brand was most used. However, both brands were made in about the same locality, from a natural rock of about the same composition, by a similar process, and both brands sold at that time for about the same price, that is from 75 to 80 cts. per bbl.

The specifications provided that, whenever the architect required it, the contractor was to make tests of the cement at his own expense, and "if not up to the standard of strength adopted it will be subject to condemnation and removal." The specifications did not state, however, what this standard of strength was, and it is not known whether any of the cement was tested or rejected.

Both of these brands of cement are still sold and samples could now be bought and tested, but it was desirable to know what strength they showed as manufactured at the time the pumping station was built. Consequently I looked up the records of cement tests made at that time in the city electrical subway and city engineer's departments. Tests of these brands made at that time in the electrical subway department showed the following average results:

Cement Mixed Neat.

Hydraulic.			Natural		
Days.	In air, lbs.	In water, lbs.	Days.	In air, lbs.	In water, lbs.
1	132	75	1	64	44
7	257	85	7	290	100
14	256	129	14	338	146
28	310	186	28	370	223

1 Part Cement to 2 Parts Sand.

No. tests made.			1	25	...
			7	43	24

Also tests were made by that department at the same time of concrete bars made with these cements, mixed 1 part cement, 3 parts sand, and 5 parts stone, or about the same as specified for the pumping station foundations. These bars were 4 × 4 × 25 ins. in dimensions, and were tested when four months old. One bar made with the brand designated "Natural" showed a modulus of rupture of 53 lbs. Two bars made with the brand designated "Hydraulic" showed moduli of rupture of 107 and 153 lbs.

Numerous tests of the "Natural" brand cement made in the city engineer's office at about the same time showed very close to these results.

With regard to the sand used in the concrete, the specifications required that it should be

> of a coarse grain, absolutely free from loam or other deleterious ingredients. The architect shall be at liberty to order the sand to be screened and washed, if he is not satisfied as to its sharpness and cleanliness.

The specifications for the stone for concrete work was that it

> must be of a good quality of either Maryland marble, granite, syenite, gneiss or trap rock. It must be crushed to a size that will pass through a two-inch ring and be screened clear of all dust and dirt. . . No slabs or thin flat stones to be allowed.

Of course the character of the sand and stone found in the concrete could be determined to some extent by observation. There appeared to be a great deal of silt and dirt and some ashes in the granular parts of the poorer concrete. The stone in the best concrete appeared to be good, hard stone and there was some such stone also in the poorer concrete, but most of the stone in the poor concrete appeared to be rotten stone.

In order to determine more definitely, however, the nature of the stone and the granular parts of the concrete and the proportion of the ingredients present I took several samples of the concrete at various points and sent them to the previously-mentioned testing laboratory for examination and analysis. These samples were taken in the most careful manner, so as to get the concrete absolutely free from any extraneous material, and so as to represent as fairly as possible a good average of the various qualities of concrete. The analysis showed the following results:

Character and Origin of Concrete Samples.

Percentages of:	Poorest, from one of west piers.	Medium, Av. of 3 from east piers.	fr	est, blanket.
Cement	0.71	2.10		25
Builder's lime	0.00	4.97		09
Stone and gravel.	37.45	74.30		40
Sand	39.80	12.75		86
Silt	18.80	5.56		29
Material dissolved other than cement.	3.24	1.22		11

Regarding the builder's lime as a p of the binder the concrete mixture was theref of the following proportions:

Parts of:	Poorest.	Me	n. Best.
Binder	1	1	1
Sand and silt	87.10	3	2.19
Stone and gravel	52.75	12	8.80

It will thus be seen that in the po t concrete there was practically no cement at , while even in the best concrete the proportion cement was 1 part to 11 parts of other materi instead of 1 part cement to 7 parts of other m rial, as called for in the specifications.

Of the concrete foundations so far ex d, the pump and stack foundations are abou of the "medium concrete" quality, while mos of the pier foundations are of a grade lower th n that, a considerable quantity being as bad as the poorest concrete or only slightly better.

With regard to the quality of the stone and sand, as shown by the analysis, the stone in the "medium" and "best" concrete was principally a good, hard gneiss, although there was considerable feldspar in the gneiss and some of the stones were large, smooth quartz pebbles. The stone in the "poorest" concrete was a soft friable stone, generally known as "rotten rock," and entirely unsuitable for the purpose. The sand and gravel found, especially in the "poorest" and "medium" concrete, was not such as would be acceptable in the best modern concrete work for such purposes, owing to the large amount of silt present.

In view of the character of the cement, as shown by the tests mentioned, and in view of the nature of the stone and sand, the presence of so much builder's lime, and the proportions of the mixture, as shown by the analyses, it would seem as if there is very little basis for any difference of opinion as to what caused the poor concrete.

The method adopted for strengthening and reconstructing the foundations is very clearly shown on the sectional elevation, Fig. 5. A brick masonry wall is being built under the four walls of the engine house, from the solid rock up to the old brick footing. This brick wall is being built in sections, in the spaces between the old concrete piers, then these piers are removed and the brick foundation is made continuous. All earth is to be excavated inside of these walls and around and under the engine foundation beds by sections. As the earth and rotten rock is excavated from under these beds they are to be temporarily shored up while the space is being filled with good concrete. The space around these beds is also to be filled solid with concrete out to the brick walls and up to an elevation 15 ft. below the present basement floor level, thus forming

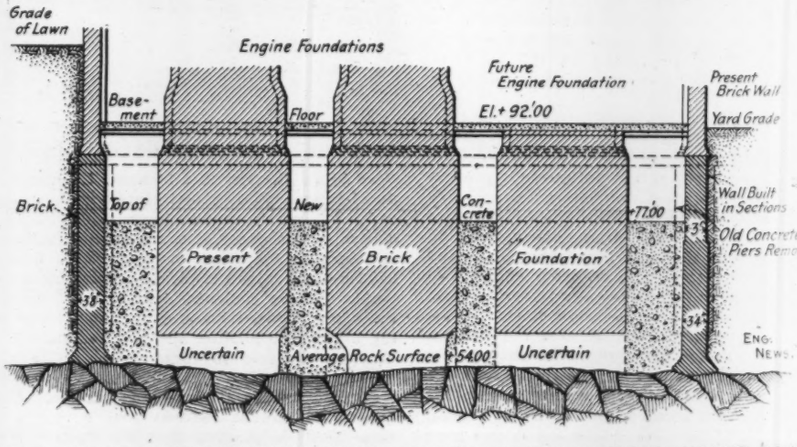

FIG. 5. PLANS FOR STRENGTHENING AND REBUILDING FOUNDATIONS, MOUNT ROYAL PUMPING STATION, BALTIMORE WATER-WORKS.

practically a sub-basement. When the new vertical triple expansion 25,000,000 or 30,000,000-gal. pump is erected in the space left for a third pump, as is planned to be done in 1909, it will set on this sub-basement floor, as will pumps of the same type and capacity that will probably be erected in the future in place of the two present 17,500,000-gal. horizontal pumps.

As I have before stated, no examination has yet been made of the foundations under the boiler house. It is quite probable that they are as bad as those already exposed under the engine house. If so, they will have to be taken out, of course, but the method which will be adopted for rebuilding or strengthening them will be determined by the condition in which they are found to be.

TESTS OF GASOLINE AND KEROSENE ENGINES WITH ALCOHOL FUEL.

By S. M. WOODWARD.*

The final report upon the investigations carried out by the U. S. Department of Agriculture upon the availability of alcohol as an engine fuel was issued recently as Bulletin 191 of the Office of Experiment Stations. These tests were conducted in the mechanical engineering laboratories of Columbia University by Prof. C. E. Lucke† and the writer. The following descriptions are condensed from the detailed accounts given in the bulletin. Some representative results and illustrations are reproduced as well as the important conclusions reached.

The specific objects of the investigations were:

First, to determine whether the gasoline and kerosene engines at present on the American market can run on alcohol as fuel. This involved as related matters the determination of the manipulation to be followed in making the engines run on alcohol, the measurement of the relative maximum powers of the engines when using alcohol and the fuels for which they were originally made, and lastly the relative consumptions of the different fuels.

Second, to determine so far as the limited time and means available permitted, the improvements which might be desirable in the design of engines manufactured especially for alcohol.

Preliminary to beginning any actual tests all the available reports upon the subject of alcohol engines in foreign countries were examined. The results of the extensive series of tests which had been carried out in both France and Germany were especially studied.

The following is a summary of the extent, scope, variety and number of the tests carried out on the various engines used. There were made 192 consumption tests on eight different engines, run on alcohol. Upward of 1,000 indicator cards were taken from the five different slow-speed engines used, and typical cards from each of the engines, running under various conditions, are reproduced in connection with the detailed results of the tests. Each of the eight engines was run on alcohol as well as on the gasoline or kerosene for which it was designed. The engines used, and the number of tests reported for each, are:

A 15-HP., 2-cylinder vertical 4-cycle Nash gasoline engine; 15 test runs.

A 6-HP. horizontal, 4-cycle International Harvester Co. gasoline engine; 24 tests with gasoline and 30 with alcohol.

A 6-HP. horizontal, 4-cycle, Weber gasoline engine; 12 tests with gasoline and 19 with alcohol.

A 6-HP. vertical, 4-cycle, Fairbanks, Morse & Co. gasoline engine; 11 tests with gasoline and 26 with alcohol.

A 6-HP. horizontal, 2-cycle, Mietz & Weiss kerosene engine; 4 tests with kerosene and 5 with alcohol.

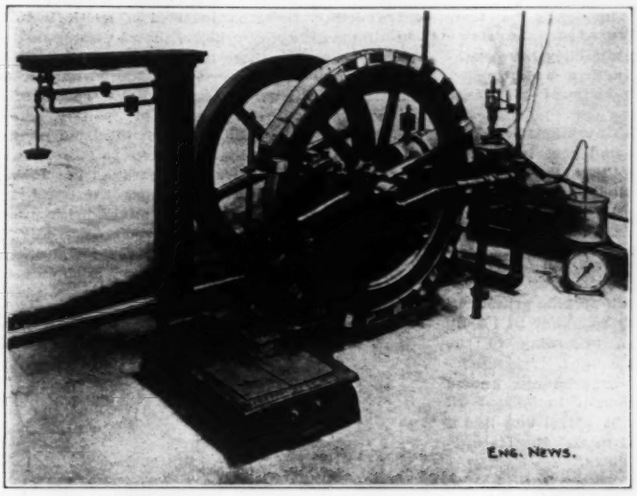

FIG. 1. HORIZONTAL 6-HP. WEBER GASOLINE ENGINE, FITTED UP FOR INDICATOR AND BRAKE TESTS ON ALCOHOL FUEL.

A 40-HP. 4-cylinder American Mercedes automobile gasoline engine; 2 runs with gasoline and 2 with alcohol.

A 40-HP., 4-cylinder, Pope-Toledo automobile gasoline engine; 12 test-runs with gasoline and 7 with alcohol.

A 20-HP. vertical, 2-cycle Mianus marine gasoline engine; 10 tests with gasoline and 7 with alcohol.

The last three of course are high-speed engines.

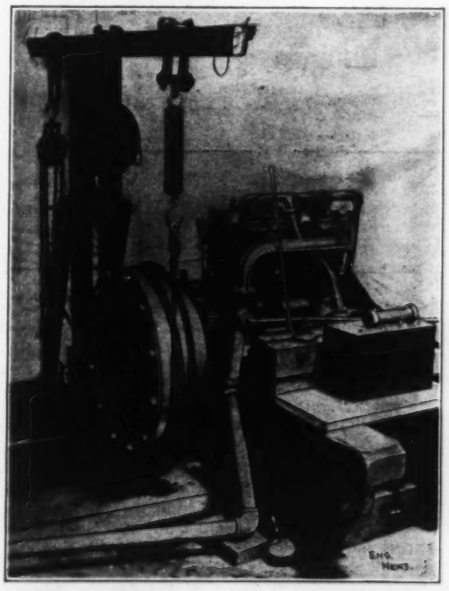

Fig. 2. Four-Cylinder 40-HP. American Mercedes Automobile Engine, Fitted Up for Brake Tests on Alcohol Fuel.

THE LIQUID FUEL.—The two most important properties of a liquid fuel, which determine its availability or adaptability for use in an engine, are its heat of combustion and its volatility.

It is readily shown from the chemical equations and the physical laws of gases that in a mixture of air and alcohol vapor in just the exact proportions for complete combustion of the alcohol by union with the oxygen of the air, the alcohol vapor must have a pressure equal to 49 mm. of mercury. If the vapor pressure is less than this amount, the oxygen is present in excess and if the vapor pressure is more, the alcohol is present in excess.

Table I. herewith gives the vapor pressure of saturation, in millimeters of mercury, for pure ethyl or grain alcohol, pure methyl or wood alcohol, a sample of gasoline, and water, at various temperatures.

From this table it is evident that ethyl alcohol can have a vapor pressure of 49 mm. only if its temperature is 72° F. or higher. Hence, a mixture of air and the alcohol vapor in the theoretical proportions for perfect combustion can not exist at a temperature below 72° F. A combustible mixture with some excess of air can exist at lower temperatures, as also a mixture in which a part of the alcohol is not in the form of vapor, but is carried with the air mechanically in the liquid form as a spray or fog.

The table shows that methyl alcohol vaporizes much more readily than ethyl alcohol and gasoline much more readily than either. A mixture of different fuels will usually have a higher vapor pressure than either of the separate ingredients unless one is present in too small a quantity to produce saturation.

Since alcohol, as used commercially, is always mixed with some proportion of water, a combustible mixture formed by the vaporization of such alcohol may become saturated with water vapor before it is saturated with alcohol and this may retard the complete vaporization of the alcohol. Such a state is more likely to occur if the air originally contains a considerable amount of water vapor—that is, if the relative humidity is high. In such a case a temperature higher than 72° would be necessary to maintain the required amount of alcohol vapor in the mixture.

In order that alcohol may change from a liquid to a vapor, it must receive a large amount of heat either from the air with which it mixes or from the metal parts of the carbureter with which it comes in contact. The hotter these parts the more quickly the alcohol can absorb the requisite amount of heat. But if the air is too hot there is danger that the mixture of air and alcohol vapor produced may be too rich in alcohol and some of the vapor must remain unburned. Still, if the air be moist, or the alcohol contain water, or the time allowed for vaporization be too short, the temperature of the air must be higher than 72° to form a proper explosive mixture.

Air at any temperature will take up some alcohol vapor, and the higher the temperature the quicker it will take up the amount necessary for the best explosive mixture. In the case of incomplete vaporization, some of the fuel may be carried along as spray, which may or may not be vaporized in the cylinder on the compression stroke. If not, it certainly will be vaporized after the explosion of the rest. It would seem desirable, therefore, to heat considerably the air supplied to an alcohol carbureter. But too much heating of the air will bring about a bad effect on the engine, because it will make the charge hotter at the end of compression, and thus decrease the weight of the charge in the cylinder. The horsepower of the engine, other things being equal, will be decreased in direct proportion as the density of the charge is lowered by this heating, so that heating of the air before car-

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TABLE I.—VAPOR PRESSURE OF SATURATION FOR VARIOUS LIQUIDS.

Temperature.		Vapor pressure of saturation in millimeters of mercury.			
°C.	°F.	Pure ethyl alcohol.	Pure methyl alcohol.	Water.	Gasoline.
0	32	12	30	5	90
5	41	17	40	7	115
10	50	24	54	9	133
15	59	32	71	13	154
20	68	44	94	17	179
25	77	59	123	24	210
30	86	78	159	32	251
35	95	103	204	42	301
40	104	134	259	55	360
45	113	172	327	71	422
50	122	220	409	92	493
55	131	279	508	117	561
60	140	350	624	149	648
65	149	437	761	187	739

bureting is good for complete vaporization, but bad if carried too far in its effect on power reduction.

METHODS OF TESTING.—Each engine tested was fitted with a brake for absorbing the power developed. Indicator cards were taken from the slow-speed engines, for which purpose a new outside spring Crosby indicator was used. The amount of fuel consumed was determined by direct weighing. The photograph Fig. 1 shows the Weber engine as fitted up ready for test, and represents the method used on the slow-speed engines. Fig. 2 shows similarly the American Mercedes engine fitted with a water-cooled rope brake as used in the tests of the large high-speed engines.

The alcohol used in these investigations was bought on competitive bids and cost in barrels 33½ cts. per wine gallon without the tax. An ultimate analysis of the alcohol gives the following composition:

	Percent.
Carbon	47.6
Hydrogen	12.7
Oxygen (by difference)	39.7

As received the alcohol had a specific gravity of 0.82 at 60° F. corresponding to about 91.1% by weight or 94% by volume, according to the Smithsonian physical tables.

The gasoline used in the experiments, known as "motor gasoline," was bought in New York City at 15 cts. a gallon by the barrel and had a specific gravity of about 0.71 at 60° F. Its ultimate composition was as follows:

	Percent.
Carbon	85.0
Hydrogen	14.8
Total	99.8

Its heat of combustion, high value, as determined by a calorimeter, was 21,120 B. T. U. per pound. The corresponding low value is 19,660.

The chemical examinations of the fuels used were made by Dr. V. J. Chambers in the chemical laboratories of Columbia University.

In making computations on the results of the tests the following weights were used:

WEIGHTS USED IN COMPUTATIONS.

Substance.	Specific gravity.	Pounds per gallon.	Pounds per pint.	Pints per pound.
Water	1.000	8.33	1.04	0.96
Alcohol	.820	6.83	.85	1.17
Gasoline	.710	5.91	.74	1.35
Kerosene	.800	6.66	.83	1.20

TESTS OF THE NASH ENGINE.

This engine is rated at 15-HP. at 280 r. p. m. It is 2-cylinder, single-acting, vertical, 4-cycle, 6½-in. bore, and 10-in. stroke. Fig. 3 illustrates by cross-sections the construction of the carbureter of this engine.

Each cylinder has two valves set in the main casing, one of which is an exhaust valve and the other an inlet valve for the mixture. Besides these two there is another valve for the admission of fuel after it is gasified. This valve, shown in the cross section of the carbureter, is operated from the main inlet valve stem by a projecting finger, allowing the fuel valve to be opened with the motion of the inlet valve or not, depending upon the governor action. When the speed rises too high the governor prevents this finger from coming in contact with the fuel-valve stem. At light loads, therefore, this valve will not open, and there will be admitted to the cylinder through the inlet valve nothing but air, which will pass through the cock designated as the "air cock." The ignition is by make-and-break mechanism.

The carbureter is of the constant-level overflow type, and is fitted with sight glasses through which the fuel level may be observed. This carbureter is really a double carbureter, or more properly a combination of carbureter and water spray. It was found by the makers of this engine that the engine under high compression may sometimes get overheated, causing pre-ignition, which can be stopped by a small injection of water with the mixture. This water injection is provided for in this carbureter by a casting, which is a double chamber. To each cylinder there is led, by way of a needle valve, a pipe from the constant-level fuel chamber and another from the constant-level water chamber, water being supplied to this chamber through the pipe tapped into the water-jacket pipe, overflowing in the usual way.

The amount of water, gasoline, or alcohol that may be supplied to the engine during the suction stroke is regulated in this carbureter by the needle valve. There are consequently four needle valves, two for gasoline, one for each cylinder, and two for water. At the top of the needle-valve orifice there is inserted a small button containing the spray orifices, shown clearly in the cross section. In these tests water was not used at any time. The operation of the carbureter is illustrated in Fig. 3, section BB. The needle valve is opened, the amount of opening being designated by the numbering on the head of the wheel, as indicated by the sharp pointer shown on the right. Air is drawn in through the downward pointing orifice and across the spraying button. This rich mixture is mixed with more air entering through the air cock. As only a portion of the air takes part in the carbureting, alcohol fuel will not have so good a chance to vaporize as it would have were the carbureter designed to take all of the vapor through the carbureting chamber.

Nash engine, of which four were with [illegible] as fuel and eleven were with alcohol [illegible]. The first six runs were made with the engi[illegible] in its ordinary condition. The compressions, measured on the indicator cards, were 67 [illegible]s. on cylinder (a) and 68 lbs. on cylinder (b).

Following these runs, compression pl[illegible] 1/16-in. thick were bolted to the inside of the [illegible]linder heads, reducing the volume of the co[illegible]ustion chamber and increasing the compressi[illegible] to 88 lbs. in cyl. (a) and 86 lbs. in cyl. (b). [illegible] next five runs were taken with this compressi[illegible] after which plates 1⅛ in. thick were put in [illegible]ace of those previously used, giving a compr[illegible]on of 111 lbs. in cyl. (a) and 107 lbs. in cyl. (b). This compression was used for the last four [illegible]ns.

Typical cards for some of these runs ar[illegible] shown in Fig. 4. Cards 1, 2 and 3 were taken [illegible] with the lowest compression while cards 13, 14 [illegible]nd 15 were taken during tests with the highe[illegible] compression.

In the reproduction of the cards no attempt was made to draw the narrow lower suction loop, but the atmospheric line is drawn in its proper relative position. Each card is marked with the number of the test to which it belongs and with the mean effective pressure determined as an average of the normal cycles on all the cards measured belonging to the same test. Where an extremely high or low cycle occurs the average mean effective pressure of such cycles is indicated, but usually the average of the normal only is given.

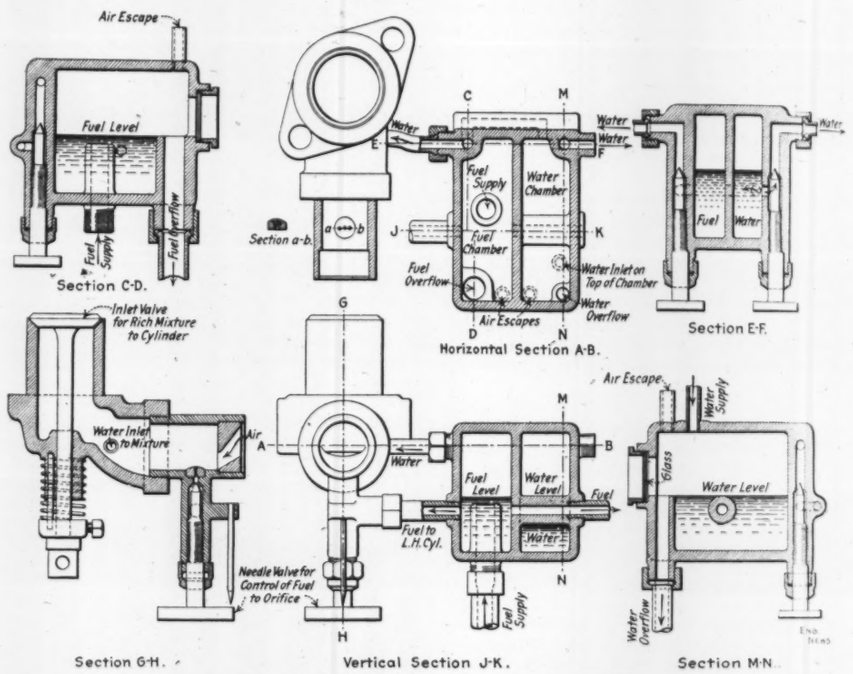

FIG. 3. CARBURETER OF THE NASH ENGINE.

During the trials it became perfectly evident that the engine operated quite satisfactorily on alcohol and quite as well as, if not better than, on gasoline. When gasoline was tried on early ignitions or high compressions the rate of propagation was so high that an explosive wave was generated. This explosive wave subjected the engine to violent shocks, which made it rock and vibrate violently and probably would have affected the bearings in time. Alcohol, on the contrary, invariably gave smooth running so that the engine was able to operate without shocks.

It also appears that not only did the engine run smoothly with alcohol, and in general more smoothly than with gasoline, but after a few days experimenting with the engine it could be started as well on alcohol as on gasoline. This is directly contrary to many of the foreign reports concerning the difficulty in starting, and which therefore seemed to call for heat in the carbureter. In our subsequent tests we found heat to be desirable, but not especially necessary for starting. Heat was necessary for complete vaporization of the alcohol, since we found that vaporization was incomplete in ordinary carbureters, as will be pointed out in the proper place.

Fifteen consumption tests were made on the

It is somewhat difficult to pick out typical indicator cards, as there were in every case several different cards on each sheet for successive strokes owing to the inability of the carbureter to maintain exactly the same mixture even when the load was steady. With light loads the governor causes the mixture valve to remain closed, but the engine gets enough air through the auxiliary air cock so that the burnt gases which are ordinarily in the clearance after an explosion are, after a miss, replaced by pure air. But with any supply of fresh air furnished to the cylinder, it is evident that if fuel is present which has been vaporized since the preceding explosion a weak explosion may be produced on a supposedly missed fuel admission. Such explosions are shown on cards 2b, 13a, 14a, 15a and 15b in Fig. 4. It was absolutely proven by close observation that these feeble cards were the result of unburned liquid alcohol subsequently vaporized and exploding during what was supposed to be a miss stroke. Later experi-

ments confirmed this conclusion, showing that the carbureter of this engine, while it may be capable of supplying enough vapor to do good work, only supplied that vapor quickly enough when excess liquid fuel is used. Excess liquid fuel so supplied will vaporize during the explosion or may lie in the passages and vaporize subsequently, during what are supposed to be miss explosions. In all cases some combustible vapor will in all probability be carried out in the exhaust pipe unburned.

The differences in fuel consumption between Tests 2 and 3, and between Tests 13 and 14, are caused by different settings of needle-valve and air cock.

Under the high compression, when using alcohol as fuel, by setting the ignitions early maximum pressures exceeding 400 lbs. per sq. in. were obtained in each cylinder, but there was at no time any audible knocking or hammering in the cylinders. Under the high compression the engine seemed slightly more sensitive to changes in adjustment, but this was not quantitatively determined.

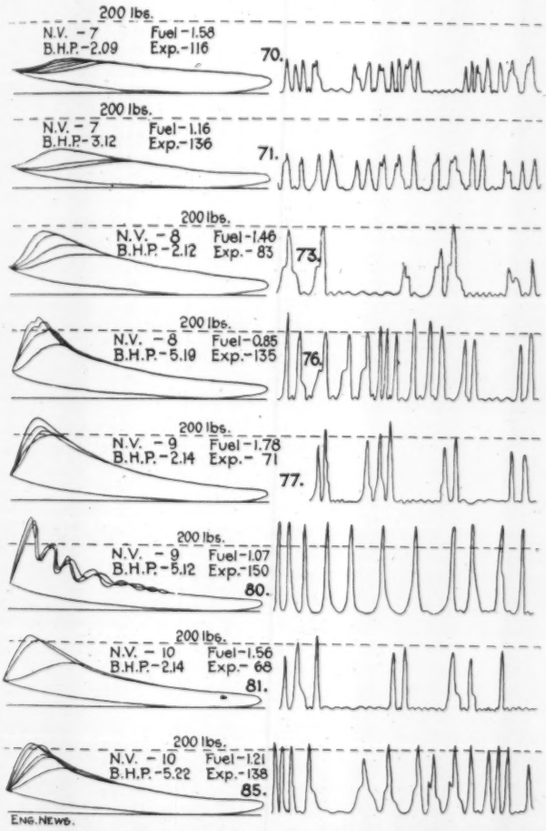

FIG. 4. SOME REPRESENTATIVE INDICATOR CARDS TAKEN DURING CONSUMPTION TESTS OF THE NASH ENGINE.

After the tests, by obstructing the overflow pipe, we backed up the fuel in the overflow chamber ½-in. or more, thus bringing it nearly to the level of the spraying orifices, and found that with suitable adjustments of the needle valves the building-up effect on the indicator cards was almost entirely eliminated. This indicates that perhaps the suction lift in the vaporizer was too great for a fuel as heavy and non-volatile as alcohol.

SUMMARY, NASH ENGINE.—(1) The engine runs as easily and smoothly on alcohol as on gasoline, and probably more noiselessly on alcohol than on gasoline.

(2) The usual gasoline carbureter may be used for alcohol, but with this carbureter the alcohol is not completely vaporized and passes into the cylinder partly in liquid form.

(3) The maximum power of the engine is distinctly greater with alcohol fuel than with gasoline.

(4) Higher compression may be used with alcohol for fuel than with gasoline.

(5) The consumption of fuel per brake horse-power, whether measured by weight or by volume, was much greater with alcohol than with gasoline.

(6) With either fuel it is very easy to use, through wrong adjustments, much more fuel than the minimum amount necessary.

(7) High compression gives a slight improvement in fuel consumption, but this improvement may very easily be more than overcome by wrong adjustment of the fuel supply.

(8) The lowest consumptions obtained were 0.71 lbs. of gasoline and 1.12 lbs. of alcohol per B. HP.-hr.

(9) The highest working mean effective pressure obtained was about 90 lbs. with both alcohol and gasoline, but at best consumption the mean effective pressures were materially lower.

INTERNATIONAL HARVESTER CO. ENGINE.

This was a horizontal single-cylinder engine, rated at 6 HP. at 300 r. p. m. The action is four-cycle, and the cylinder is 5½-in. bore by 9-in. stroke, and water cooled. The compression, as determined by indicator cards, is 73 lbs. per sq. in.

The carbureter is shown in cross-section in Fig. 5. The engine governs by the hit-and-miss principle, but in a way quite different from that used in the Nash engine. During the miss strokes the exhaust gases are drawn into and expelled successively from the cylinder, whereas in the Nash engine during a miss stroke fresh air was drawn in and passed out.

The carbureter is attached directly to the inlet opening and is of the constant-level overflow type supplied by a pump. All of the air used by the engine passes through the carbureter chamber and meets the spray at the orifice.

It became clear during the tests on the Nash engine that an apparently insignificant change in the carbureter setting might possibly have a very large effect on the fuel consumption. It also became clear that the adjustment of the igniter and carbureter were matters of much greater importance in fuel economy than a considerable change in compression. To put it otherwise, increasing the compression of an engine using alcohol fuel, for the purpose of obtaining a gain in economy, might be entirely useless if the engine were unskillfully handled, and although with the best adjustments for both high and low compressions the former show better results in economy than the latter, the results are not so much better but that they might be overbalanced by the bad effects resulting from a poor adjustment of the engine. In spite of considerable care in determining the best adjustment, it was not always easy to say that it had been reached. With these things in mind it was decided in the tests on the International Harvester Co. engine to investigate the maximum possible fuel consumption for all settings of the carbureter just as carefully as the minimum fuel consumption for good settings of the carbureter.

The results of the 54 test-runs are given in Table II.

Under each fuel the tests are arranged on the same plan. All runs with different needle-valve settings on the same approximate brake horsepower are grouped together, those with the greatest horsepower being placed first, and the successive groups being placed in order down to the zero brake load. In each case the smallest needle-valve opening was the least with which the engine would continue to run with its imposed load, and similarly the maximum opening was the limiting setting under which the engine could carry the load; except that with some of the intermediate and low brake loads, where for lack of time only one or two runs were taken, the settings were intended to be about those for maximum economy. The minimum needle-valve settings were quite definite in position, one notch

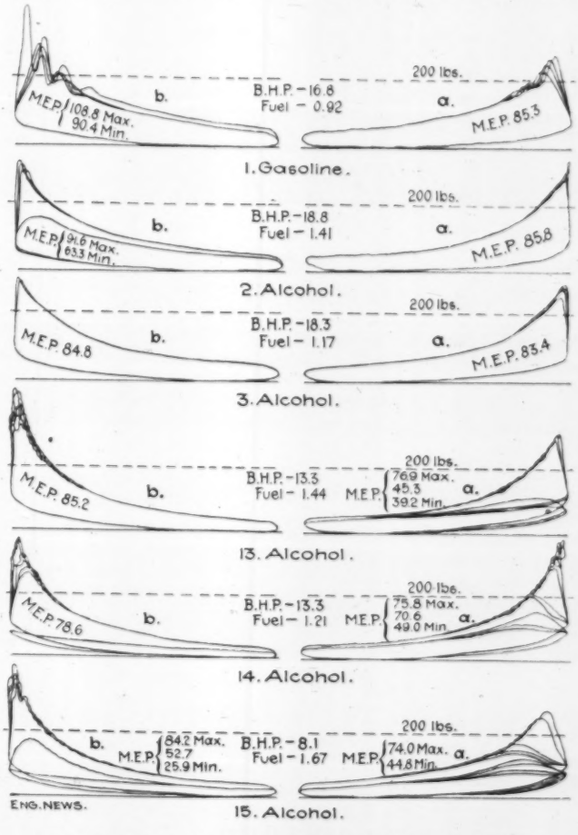

FIG. 8. SOME INDICATOR-CARDS FROM THE WEBER ENGINE, WITH GASOLINE FUEL.

usually making a distinct difference in the operation of the engine. The maximum needle-valve openings were not so definite, and in some cases a variation of several notches from those given in the table might exist.

Since the point of ignition was not easily changed and could not be measured without stopping the engine, time did not permit an extended investigation of its influence. In the earlier runs it was changed to the supposedly best position, as shown by indicator cards, for each separate run and its value was not measured. In the later runs two values of the points of ignition were used, one when the piston was ¼-in., or 2.8%, before the end of its stroke, which was used for all the gasoline runs and for part of the alcohol runs, and which was apparently about the best position for the most explosive alcohol mixtures; the other at ⅝-in., or 6.9%, before the end of the stroke, used for part of the alcohol runs and apparently about the best point for the extreme alcohol mixtures.

The number of explosions per minute was con-

stantly fluctuating and hence is a very uncertain element. Moreover, it was evident in some cases that when the indicator cock was opened for the purpose of taking cards a change was produced in the number of missed fuel admissions. Likewise, the mean effective pressure is difficult to determine accurately from the indicator cards. However, a number of cards were taken for each run and each card contained a large number of cycles. The average cycle on each card was estimated and the results obtained on the different cards were averaged. It seems probable that the final mean effective pressure obtained could be in error by not more than 2 lbs. The corresponding number of explosions might be in error three or four. On account of the uncertainty of these elements considerable uncertainty attaches to the values of I. H.P. However, the variations for any given B. HP. are no more than might be expected under the conditions involved. In obtaining the area of the indicator cards only the upper loop was taken; hence the indicated horsepower has not been corrected for the negative work of the suction loop.

The mechanical efficiency, obtained by dividing the brake horsepower by the indicated horsepower found as described above, includes all the errors in the several measurements taken and shows variations accordingly. The thermal efficiency is given for each test, based upon the low heat values of the fuels. The values used were 19,660 B. T. U. per pound of gasoline and 10,620 per pound of alcohol. The thermal efficiency was calculated for each case by dividing 2,545 by the product of the low heat value and the consumption in pounds per brake horsepower hour.

The consumptions for most of the tests reported in Table II. are plotted in Fig. 6, with respect to needle-valve settings. Points corresponding to the same brake horsepower are connected by curves and the horsepower is marked on each curve.

Comparing the needle-valve settings used with gasoline and alcohol, it appears that the proper setting for alcohol is about double that for gasoline, and that the minimum opening under which the engine would run on alcohol was found just about the maximum opening under which the engine would run with gasoline.

In making the tests at maximum load it was very evident that with alcohol the load could be carried materially higher than with gasoline.

The tables show a rather definite relation between the maximum pressure and the nature of the combustion. With gasoline as fuel, a maximum pressure less than 240 lbs. per sq. in. indicates slow combustion; from 240 to 300 lbs. per sq. in. indicates normal combustion, and a higher pressure than the latter figure indicates an explosive wave. With alcohol as fuel, the limits for normal combustion are slightly narrower than for gasoline, being about 250 and 290 lbs. per sq. in., respectively.

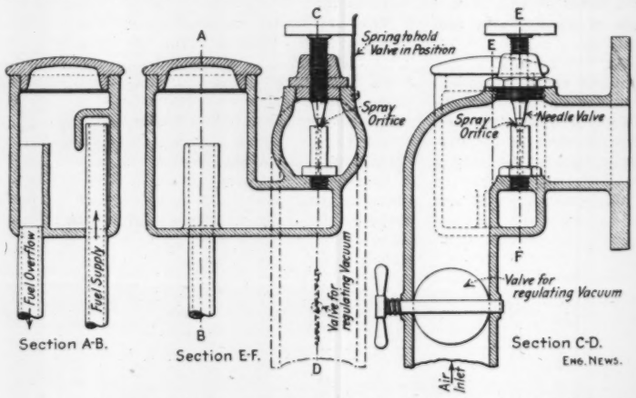

FIG. 5. CARBURETER OF INTERNATIONAL HARVESTER CO. ENGINE.

SUMMARY, I. H. CO. ENGINE.—(1) With both alcohol and gasoline fuel, from half load to full load, the best consumptions were obtained with the smallest needle-valve settings which could be used with the respective fuels and loads.

(2) With both alcohol and gasoline fuel, by opening the needle valve the consumption could be increased to approximately twice the best consumption before the engine would be stopped by the excess of fuel.

(3) With both alcohol and gasoline, the most rapid combustion, the highest mean effective pressure and the highest maximum pressure were obtained when the fuel used was considerably in excess of the best consumption.

(4) With both alcohol and gasoline, the am[illegible] of fuel used with any given load was approximately [illegible]portional to the needle-valve setting.

(5) The minimum needle-valve setting for [illegible]hol was about double the minimum setting for gasoli[illegible]d about equal to the maximum setting possible for th[illegible]me load with gasoline.

(6) With alcohol fuel, using a slow-burning [illegible]ute fuel mixture, the consumption was perceptibly [illegible]roved by using a very early ignition.

(7) The mean effective pressure and the [illegible]aximum explosion pressure were about the same for [illegible] alcohol and gasoline at best consumption.

(8) The highest mean effective pressures ob[illegible]ned with alcohol were appreciably greater than the h[illegible]hest obtained with gasoline.

(9) The maximum power obtainable from [illegible] engine was appreciably h[illegible]r with alcohol than with [illegible]oline.

(10) Much mo[illegible] alcohol could be supplied [illegible] the engine cylinder than [illegible]ould be vaporized in the [illegible]bureter, so that liquid alcoh[illegible] entered the cylinder.

(11) With alcohol the engine would run on [illegible] greater range of misadjustment than with gasoline.

(12) The best consumption results obtained were 0.69 lbs. of gasoline and 1.23 lbs. of alcohol per B. HP. hr.

(13) At best consumptions the mean effective pressures were 90 lbs. for both alcohol and gasoline.

THE WEBER ENGINE.

This engine was quite similar to the engine just described and the tests with it confirmed in general the conclusions already obtained. The diagram Fig. 7 shows the results of the consumption tests using gasoline fuel. The needle-valve setting and brake horsepower are taken as axes of coordinates. At the appropriate points in the diagram the consumptions in pounds per brake horsepower-hour are marked. With these points as guides, lines are drawn through points of equal consumption. These lines are drawn for consumptions varying from 0.9 to 1.6 lbs. per HP.-hr.

From the figure it is evident that the best consumption is obtained at full load, with nearly the minimum possible needle-valve setting. The consumption rapidly increases as the load is diminished or the needle-valve setting increased.

TABLE II.—INTERNATIONAL HARVESTER CO. ENGINE. RESULTS OF FUEL-CONSUMPTION TESTS.

No. of test.	Point of ignition, °	Needle valve setting.	Rev. per. min.	Brake HP.	Fuel consumption per B. HP. hour. Lbs.	Fuel consumption per B. HP. hour. Galls.	Explosions per min.	M. E. P. lbs. per sq. in.	Indicated HP.	Mechanical efficiency, %	Ther. eff. based on low calorific power, %.	Max. pres., lbs. per sq. in.	Nature of combustion.
					Gasoline Fuel.								
16	−2.8	15	291	6.13	1.22	0.21	130	102.0	7.15	86	10.6	340	Explosive wave.
17	−2.8	12	290	5.57	.69	.12	133	89.5	6.44	86	18.8	250	Normal combustion.
18	−2.8	15	293	5.63	.79	.13	126	99.1	6.75	84	16.4	370	Explosive wave.
19	−2.8	18	292	5.61	1.14	.19	131	96.0	6.80	82	11.4	310	Do.
20	−2.8	20	290	5.57	1.33	.22	136	92.9	6.83	82	9.7	255	Do.
21	.....	15	288	5.37	.97	.16	138	90.0	6.71	80	13.4	240	Normal combustion.
22	.....	14	286	5.34	.93	.16	143	94.8	7.33	73	13.9	305	
23	−2.8	12	290	5.03	.76	.13	127	86.1	5.91	85	17.1	240	Slow combustion.
24	−2.8	13	289	5.02	.82	.14	127	90.6	6.22	81	15.8	300	Normal combustion.
25	−2.8	14	290	5.03	.89	.15	123	93.6	6.22	81	14.6	305	Do.
26	−2.8	15	291	5.05	.95	.16	121	97.3	6.32	80	13.6	325	Explosive wave.
27	−2.8	18	291	5.05	1.21	.20	129	92.4	6.47	78	10.7	250	Normal combustion.
28	−2.8	20	289	5.02	1.69	.29	130	89.5	6.30	80	7.7	250	Slow combustion.
29	.....	14	292	4.36	.99	.17	111	96.0	5.76	76	13.1	280	
30	−2.8	11	290	3.41	1.01	.17	130	75.2	5.29	64	12.8	150	Very slow burning.
31	−2.8	12	291	3.42	1.00	.17	108	85.0	4.96	69	13.0	225	Normal combustion.
32	−2.8	22	291	3.42	2.36	.40	131	69.9	4.80	71	5.5	165	Very slow burning.
33	.....	14	296	2.76	1.27	.21	82	95.2	4.22	65	10.2	260	
34	.....	14	296	2.77	1.12	.19	78	92.5	3.90	71	11.6	250	
35	−2.8	11	291	1.79	1.77	.30	107	83.0	4.80	37	7.3	225	Normal combustion.
36	−2.8	25	291	1.79	5.13	.87	126	58.6	3.99	45	2.5	150	Very slow combustion.
37	.....	14	300	1.12	2.54	.43	53	89.2	2.56	44	5.1	225	
38	.....	14	300	1.12	2.14	.36	53	91.9	2.63	43	6.1	225	
39	.....	14	290	.00	[1.58 total]	...	28	89.5	1.38	..	...	225	
					Alcohol Fuel.								
40	−6.9	25	289	6.09	1.25	0.18	136	92.0	6.77	90	19.2	280	Normal combustion.
41	−6.9	30	288	6.07	1.61	.24	130	101.0	7.07	86	14.9	390	Explosive wave.
42	−2.8	30	288	6.07	1.64	.24	140	96.3	7.29	83	14.6	280	Normal combustion.
43	−2.8	33	289	6.09	1.84	.27	138	97.0	7.24	84	13.0	280	Explosive wave.
44	−6.9	42	288	6.07	2.32	.34	130	102.0	7.16	85	10.3	315	Normal combustion.
45	.....	25	288	5.91	1.44	.21	134	95.0	6.88	86	16.7	280	Explosive wave.
46	.....	35	289	5.39	2.34	.34	132	95.6	6.82	79	10.2	240	Slow combustion.
47	−6.9	22	289	5.02	1.23	.18	126	89.8	6.11	82	19.5	275	Normal combustion.
48	−2.8	23	292	5.06	1.33	.20	134	89.5	6.48	78	18.0	240	Slow combustion.
49	−2.8	25	290	5.08	1.41	.21	122	93.4	6.16	82	17.0	260	Normal combustion.
50	−2.8	30	291	5.05	1.78	.26	116	104.5	6.57	77	13.5	315	Explosive wave.
51	−2.8	35	290	5.03	2.14	.31	116	105.7	6.64	76	11.2	305	Do.
52	−2.8	43	290	5.03	2.86	.42	128	92.4	6.40	79	8.4	225	Slow combustion.
53	−6.9	51	288	5.00	3.00	.44	109	100.0	6.25	80	8.0	275	Explosive wave.
54	.....	25	296	4.42	1.57	.23	100	100.0	5.40	82	15.3	305	Normal combustion.
55	−6.9	20	291	3.42	1.55	.23	115	84.5	5.25	65	15.5	20	Do.
56	−2.8	22	292	3.43	1.69	.25	113	83.3	5.09	67	14.2	215	Slow combustion.
57	−2.8	25	293	3.44	1.71	.25	94	94.6	4.80	69	14.0	280	Normal combustion.
58	−2.8	30	296	3.48	1.97	.29	83	110.2	4.96	70	12.2	305	Explosive wave.
59	−2.8	35	296	3.48	2.46	.36	85	108.5	4.98	70	9.7	290	Do.
60	−2.8	50	293	3.44	4.32	.63	120	75.2	4.88	70	5.6	185	Slow combustion.
61	.....	25	298	2.78	1.87	.27	68	104.5	3.73	75	12.8	280	Explosive wave.
62	−2.8	22	293	1.81	2.70	.40	86	79.3	3.69	49	8.9	210	Slow combustion.
63	−2.8	25	296	1.82	2.65	.39	75	97.0	3.96	46	9.1	260	Normal combustion.
64	−2.8	30	298	1.84	2.98	.44	62	107.3	3.60	51	8.0	290	Do.
65	−2.8	35	298	1.84	3.56	.52	63	109.0	3.71	50	6.7	275	Explosive wave.
66	−2.8	50	298	1.84	4.68	.69	57	91.0	2.81	66	5.1	190	Slow combustion.
67	−2.8	525	295	1.82	8.70	1.28	37	126.0	2.52	72	2.8	315	Explosive wave.
68	.....	25	302	1.13	3.20	.47	39	108.0	2.24	50	7.5	280	Normal combustion.
69	.....	25	304	.....	[2.14 total]	...	14	96.6	.73	..	...	190	Do.

Fig. 5 shows indicator cards for some of these tests, numbered to correspond with the number of the test. Such cards were selected as would represent best the variations in the cards obtained during each test. Each card is marked with the needle-valve setting, the brake horsepower, the fuel consumption in lbs. per B. HP. and the number of explosions per minute. The engine was running at about 300 r. p. m. As soon as each card was taken in the usual way, the paper was inverted on the indicator drum and with the pencil in contact with the paper the indicator string was slowly pulled by hand. In this way a toothed line was produced showing many successive explosions and misses. The object of doing this was to observe the sequence of explosions as shown by the relative heights of the cards and the corresponding maximum pressures. Adjacent to each card a portion of this jagged line is shown. In all cases the line was traced by the indicator pencil from left to right. It was impossible to pull the string at a constant steady rate, so the successive cycles are not equally spaced along the line.

These lines show great irregularity in the order of succession and in the strength of the different explosions. They illustrate strikingly the difficulty of obtaining an accurate average mean effective pressure for use in computing an indicated horsepower. The indicator cards show in general the same relations as found with the International Harvester Co. engine. When the fuel supplied is slightly in excess of the amount corresponding to the best consumption, the combustion is most rapid and the highest mean effective pressures are attained. When the engine was working nearly up to full load and an abundance of fuel was supplied, it was observed that as the cylinder became hotter during a test the nature of the combustion was changed. In some cases at the beginning of a test the indicator cards showed no evidence of explosive waves, but before the test was over every explosion produced explosive waves.

SUMMARY, WEBER ENGINE.—(1) Variations of fuel consumption with different adjustments of the needle valve as found in the International Harvester Co. engine were confirmed.

(2) Different indicator cards taken in succession vary greatly in shape and area, showing great irregularity in mean effective pressure.

(3) Slow speeds gave a better alcohol fuel consumption than high speed.

(4) Water injected into the exhaust pipe increased the consumption of alcohol fuel.

(5) Very early ignition much improved the alcohol fuel consumption with the weak mixture used.

OTHER ENGINES.

Space will permit only a bare mention of the other engines tested.

The Fairbanks, Morse & Co. engine had a throttling governor and had been arranged to give very high compression of 128 lbs. as shown by the indicator cards. No entirely satisfactory gasoline consumption tests could be obtained, because the high compression produced pre-ignition and violent hammering. Short runs showed approximately the same gasoline consumption as other engines using lower compression. The operation of the engine with alcohol was entirely satisfactory with this high compression, and the best alcohol consumption obtained was 1.13 lbs. per B. HP.-hr. As compared with the other engines tested, there was only a slight improvement in consumption, due to the higher compression used.

After the first tests had been completed, apparatus was arranged to heat the air entering the carbureter to any temperature desired up to 150° F. With the air entering the carbureter heated to 125° F., the engine would self-ignite with alcohol fuel, but this preignition caused no hammering in the engine cylinder and was in no way objectionable in the operation of the engine. With the air entering the carbureter heated to 150° F., preignition took place so early as to reduce the maximum power of the engine, but otherwise it continued to run satisfactorily. The use of heated air produced no appreciable change in the fuel consumption.

The other engines tested ran as successfully and easily on alcohol fuel as the ones above mentioned and showed the same general results.

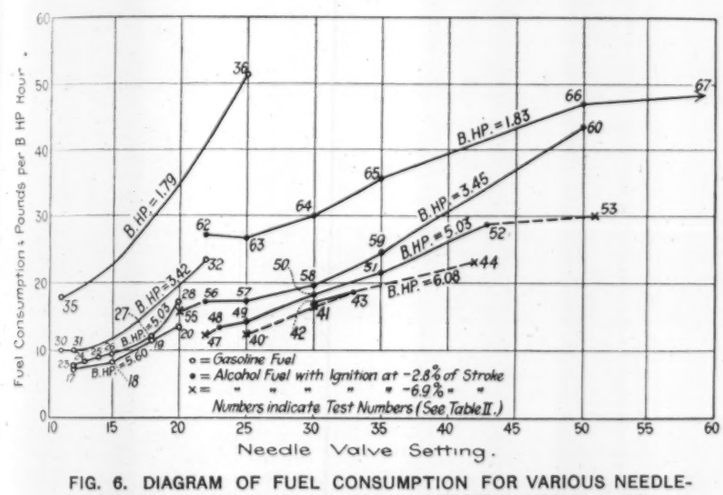
Fuel Consumption, Pounds per B HP Hour.
Needle Valve Setting.
B.HP. = 1.79
B.HP. = 3.42
B.HP. = 5.60
B.HP. = 1.83
B.HP. = 3.45
B.HP. = 5.03
B.HP. = 6.08
o = Gasoline Fuel
• = Alcohol Fuel with Ignition at -2.8% of Stroke
× = " " " " " -6.9% " "
Numbers indicate Test Numbers (See Table II.)

FIG. 6. DIAGRAM OF FUEL CONSUMPTION FOR VARIOUS NEEDLE-VALVE SETTINGS AND VARIOUS HORSEPOWERS, I. H. CO. ENGINE.

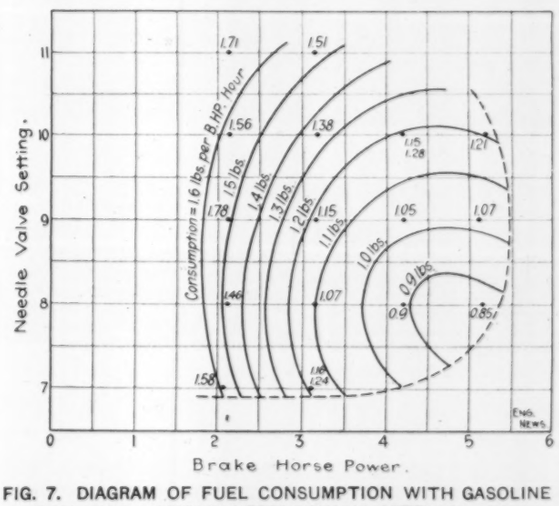

FIG. 7. DIAGRAM OF FUEL CONSUMPTION WITH GASOLINE FUEL FOR VARIOUS NEEDLE-VALVE SETTINGS AND VARIOUS HORSEPOWERS; WEBER ENGINE.

As an indication of the results obtained with the high-speed engines the summary of results for the Pope-Toledo engine may be quoted:

(1) As satisfactory operation of the engine and as high a power was obtained when the engine was running on alcohol fuel as when it was using gasoline fuel.

(2) When alcohol was used, but a small proportion of the liquid was vaporized in the carbureter. The remainder of the fuel supplied must have been carried along with the air as a liquid spray. This was shown by the low temperature of the fuel mixture after leaving the carbureter, and also by the fact that at low loads not all the cylinders could get an explosive mixture.

(3) The fuel consumption per brake horsepower-hour was increased by opening materially either the fuel needle-valve or the throttle valve beyond the settings necessary to carry the load.

(4) With gasoline fuel the consumption per brake horsepower-hour did not appear to vary so much with the load as it did when alcohol fuel was used.

(5) With gasoline fuel the best consumption was 0.69 lb. per B.HP.-hour.

(6) With alcohol fuel the best consumption obtained was 1.30 lbs. per B.HP.-hr. at the highest load obtained—18 B.HP.

CONCLUSIONS.

The following general conclusions are drawn as a result of the investigations:

(1) Any gasoline engine of the ordinary types can be run on alcohol fuel without any material change in the construction of the engine. The only difficulties likely to be encountered are in starting and in supplying a sufficient quantity of fuel, a quantity which must be considerably greater than the quantity of gasoline required.

(2) When an engine is run on alcohol its operation is more noiseless than when run on gasoline, its maximum power is usually materially higher than it is on gasoline and there is no danger of any injurious hammering with alcohol such as may occur with gasoline.

(3) For automobile air-cooled engines alcohol seems to be especially adapted as a fuel, since the temperature of the engine cylinder may rise much higher before auto-ignition takes place than is possible with gasoline fuel, and if auto-ignition of the alcohol fuel does occur no injurious hammering can result.

(4) The consumption of fuel, in lbs. per B.HP.-hr., whether the fuel is gasoline or alcohol, depends chiefly upon the load at which the engine is being run and upon the setting of the fuel supply valve. It is easily possible for the fuel consumption per horsepower hour to be increased to double the best value, either by running the engine on a load below its full power or by a poor setting of the fuel supply valve.

(5) These investigations also showed that the fuel consumption was affected by the time of ignition, by the speed, and by the initial compression of the fuel charge. No tests were made to determine the maximum possible change in fuel consumption that could be produced by changing the time of ignition, but when near the best fuel consumption it was shown to be important to have an early ignition. So far as tested the alcohol fuel consumption was better at low than at high speeds. So far as investigated, increasing the initial compression from 70 to 125 lbs. produced only a very slight improvement in the consumption of alcohol.

(6) It is probable that for any given engine the fuel consumption is also affected by the quantity and temperature of cooling water used and the nature of the cooling system, by the type of ignition apparatus, by the quantity and quality of lubricating oil, by the temperature and humidity of the atmosphere, and by the initial temperature of the fuel.

(7) It seems probable that all well-constructed engines of the same size will have approximately the same fuel consumption when working under the most advantageous conditions.

(8) With any good small stationary engine as small a fuel consumption as 0.70 lb. of gasoline, or 1.16 lbs. of alcohol per B.HP.-hr. may reasonably be expected under favorable conditions. These values correspond to 0.118 and 0.170 gal. respectively, or 0.95 pint of gasoline and 1.36 pints of alcohol. Based on the high calorific values of 21,120 B.T.U. per pound of gasoline and 11,880 per pound of alcohol, these consumptions represent thermal efficiencies of 17.2% for gasoline and 18.5% for alcohol. But calculated on the basis of the low calorific values of 19,660 B.T.U. per lb. for gasoline and 10,620 for alcohol, the thermal efficiencies become 18.5% for the former fuel and 20.7% for alcohol. The ratio of the high calorific values used above is, gasoline to alcohol, 1.78. The corresponding ratio of the low calorific values is 1.85. The ratio of the consumptions mentioned above is, alcohol to gasoline, 1.68 by weight, or 1.44 by volume.

No tests were run on denatured alcohol because this is not a definite chemical substance, and hence quantitative results would have no standard value. But since denatured alcohol differs in its physical properties from ethyl alcohol only in being slightly more volatile, it is evident that any engine able to run on ethyl alcohol would operate at least as easily on denatured alcohol.

These investigations showed that while ordinary gasoline engines as now constructed will operate on alcohol fuel, special devices are needed for starting at low temperatures, such as either an independently heated carbureter or a means of temporarily supplying gasoline until the engine becomes heated. Furthermore, with the usual form of unheated spray carbureter all sharp bends between the spray nozzle and the cylinder should be eliminated in order to avoid the separator action which tends to remove the particles of liquid spray from the air current carrying them along.

THE MECHANICAL FILTER PLANT at Louisville, Ky., which has been under construction for some years past, is now being given preliminary tests prior to being put into continuous operation. In all the tests thus far, the coagulant used has been sulphate of alumina. Mr. S. Bent Russell, M. Am. Soc. C. E., is the recently appointed Chief Engineer of the company, to succeed the late Mr. Charles Hermany.

THE CONSTRUCTION OF A COMBINED SMOKESTACK AND WATER TANK.

By H. STOFFELS.*

The combination of an elevated water tank with a brick smokestack which carries the tank but projects through and above it may be seen all over Europe.† Most industrial plants require elevated water storage as well as a chimney; the combined construction saves the cost and space of a separate foundation and supporting structure for the tank, and uses the heat of the chimney to protect the stored water from freezing. The design and erection of these structures involve no special difficulty, and it is immaterial for the erection whether the chimney be first built complete or whether the tank be put in place as soon as the chimney has been built up to the stone corbel ring on which the tank rests.

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†A note on this combination construction, illustrated by an elevation and vertical section, appeared in Engineering News of May 5, 1898, p. 287, where the invention is credited to Prof. O. Intze (now deceased) and Mr. F. A. Neumann. A large number of such structures, we understand, has been built by the firm of F. A. Neumann, Eschweiler, Germany.

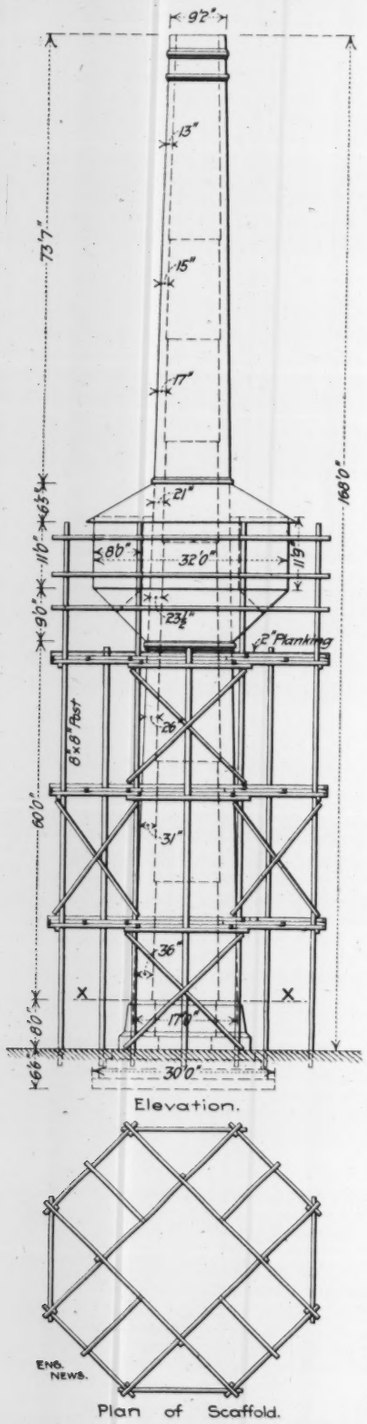


Fig. 1. Elevation of 168 x 7-ft. Brick Smokestack Carrying 60,000-Gallon Tank, and Riveting Scaffold for Erection of Tank.

The drawings, Figs. 1 and 2, herewith show the dimensions and details of a 168 × 7-ft. chimney carrying a 60,000-gal. tank 68 ft. above ground level. The tank is annular, 16 ft. inside diameter and 32 ft. outside diameter, by 11 ft. 9 ins. high in the straight portion. The bottom is hopper-shaped, and its outer cone extends down and inward to the wall of the chimney, where it foots on a ring of first-class sandstone built in the brickwork. Neither the tank itself nor the sloping roof over the tank touches the chimney, but a narrow projecting belt-course projecting from the chimney wall covers the joint and keeps out rain and cinders. The drawing Fig. 2 shows the structural details of the tank.

In erecting this tank, the lower cone, comprising a ring of two angles, six tapered and curved side sheets, six pairs of stiffener tees and a top angle ring, is first put up, by hoisting the material and supporting it from a scaffolding built up from the ground until it is riveted together. Then the material for the inner and outer cones of the hopper-shaped bottom is hoisted up and riveted in place, using the scaffold and the lower cone as supports. Then the plates of the inner and outer cylindrical walls are put in place and riveted row by row, the riveters working on platforms built inside the tank and in the annular space between tank and chimney. The roof is placed preferably after the brickwork has been carried up above the level of the tank.

STRESSES IN CHIMNEY.—The calculation of the stresses in the stack, to determine its wall thickness, etc., is done by exactly the same method as used for a chimney without a tank. To illustrate, the chimney shown will be analyzed for the stresses at the bottom, Section X-X.

The wind is assumed to have a pressure of 26 lbs. per sq. ft. against both stack and tank. The total wind-pressure then is 57,700 lbs., and its lever-arm above X-X is 72 ft. The wind moment on section X-X is therefore 4,154,000 ft.-lbs.

Weight of stack above section X — X	1,525,000 lbs.
Estimated weight of tank	50,000
Weight of water in tank	500,000
Total weight: Tank empty	1,575,000 lbs.
Tank full	2,075,000 lbs.

Area of cross-section of brickwork at X — X:

$$\frac{\pi}{4}(17^2 - 11^2) .144 = 19{,}000 \text{ sq. ins.}$$

Moment of resistance of section X — X:

$$\frac{\pi}{32}\left(\frac{17^4 - 11^4}{17}\right)12^2 = 686{,}000 \text{ ins.}^3.$$

Hence the distance of the resultant line from the center of the section X-X:

Tank empty: $\dfrac{4{,}154{,}000.12}{1{,}575{,}000} = 31.6$ ins.

Tank full: $\dfrac{4{,}154{,}000.12}{2{,}075{,}000} = 24$ ins.

The maximum stresses in the brickwork are:

Tank empty:

$$\frac{1{,}575{,}000}{19{,}000} \pm \frac{4{,}154{,}000 \times 12}{686{,}000}$$

= 156 lbs. per sq. in. leeward
10 lbs. per sq. in. windward.

Tank full:

$$\frac{2{,}075{,}000}{19{,}000} \pm \frac{4{,}154{,}000 \times 12}{686{,}000}$$

= 182 lbs. per sq. in. leeward
87 lbs. per sq. in. windward.

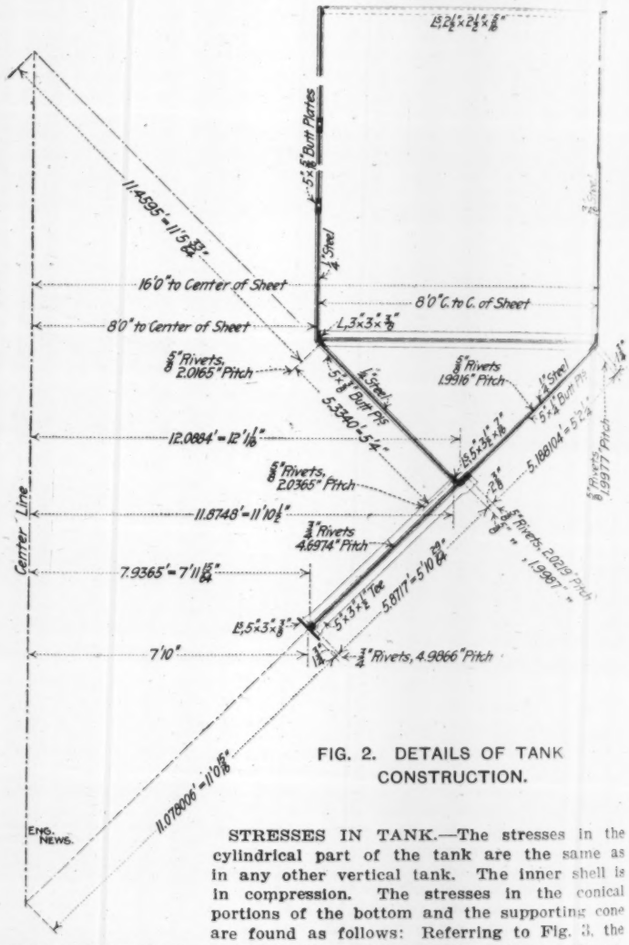


FIG. 2. DETAILS OF TANK CONSTRUCTION.

STRESSES IN TANK.—The stresses in the cylindrical part of the tank are the same as in any other vertical tank. The inner shell is in compression. The stresses in the conical portions of the bottom and the supporting cone are found as follows: Referring to Fig. 3, the weight of the water column resting on the entire width of the outer cone *a b* is 289,800 lbs., all of which is carried to point *a*. Since the inclination of the bottom is 45°, the reaction of *e a* is, per foot of circumference,

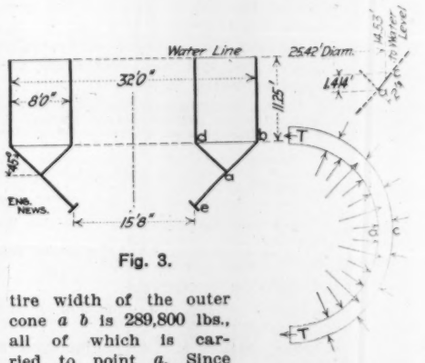


Fig. 3.

$$\frac{289{,}800}{\pi \times 24 \times \cos 45} = 5{,}435 \text{ lbs.}$$

Considering the strip $a\ c$, 2 ft. wide, cut away, the weight on $c\ b$ is 187,000 lbs., all of which is carried to c, and the pressure along $c\ a$ is, per foot of circumference,

$$\frac{187{,}000}{\pi \times 26.82 \times \cos 45} = 3{,}140 \text{ lbs.}$$

The ring $a\ c$ is represented in half plan in Fig. 3. The horizontal forces acting upon the half ring are the horizontal components of the reaction of $e\ a$ upon $a\ c$ and of the load from $c\ b$, the horizontal component of the water pressure on $a\ c$, and the tensions T at the free ends of the half ring. Their equilibrium gives the equation

$$5{,}435 \times 0.707 \times 24 - 3{,}140 \times 0.707 \times 26.82 + 1.414 \times 14.53 \times 62.5 \times 25.42 - 2\ T = 0$$

from which

$$T = 32{,}600 \text{ lbs.}$$

This is the circumferential tension in the lower 2 ft. of the outer cone. The tension per foot is half of this, or 16,300 lbs.

In addition to the ring tension, the cone $a\ b$ sustains compression along its inclined surface. The stresses in the inner cone $a\ d$ are found in the same way, but both the meridian stress and the circumferential stress are compression. They are small, in general, and therefore require little material, but as they are compression, double butt-plates have been used on both the vertical and the horizontal joints.

The ring at point a, Fig. 3, sustains a ring tension of about 73,200 lbs., which is easily taken up by the material used (see Fig. 2).

The entire weight of tank and water is 538,500 lbs. The component along $a\ e$ is 762,500 lbs., which is transmitted to the stone footing ring by six pairs of 5 × 3 × ½-in. tees used as stiffeners at the joints of the separate plates of the cone.

ROLLING-LIFT BASCULE BRIDGE FOR THE BALTIMORE & OHIO RY. AT CLEVELAND, OHIO.

In the improvement of the Cuyahoga River at Cleveland, Ohio, to develop harbor facilities and to facilitate navigation by large steamers of the modern type, about 20 railway and highway bridges have to be dealt with. Some of the swing bridges have been replaced by bascule bridges in order to give a clear channel and to render available the dock frontage formerly obstructed by swing bridges (especially with the pivot piers close to the shore line). One of the latest of these structures is a single-leaf bascule bridge on a line of the Baltimore & Ohio Ry. extending to extensive ore docks, and carries the railway over a branch of the river known as the Old Ship Channel. The old swing bridge had its pivot pier on the west side, while the approach on the opposite side extended into the channel. The new structure has the main pier on the east side, with a rest pier on the edge of the west side. This arrangement gives the entire width of channel for navigation, and also enables the dock frontage to be utilized up to the bridge piers.

The bridge is of the Scherzer rolling-lift type, and is a single-leaf, single-track structure with a span of 230 c. to c. of bearings. It is said to be the longest single-leaf bascule bridge ever built. The clear width of channel is 210 ft. between faces of piers. The total length of the steel work, including a short fixed plate-girder approach span at the east end, is 334 ft. The bridge has through trusses 20 ft. c. to c., and the minimum clearance above the ties is 22 ft. It is counterweighted so as to be balanced in all positions, the counterweights being of concrete placed in steel boxes in the planes of the trusses. The substructure consists of three piers at the heel end (carrying the track girders on which the bridge rolls), a rest pier, and an abutment for the rear end of the fixed approach span at the heel. These are all of concrete, supported on piles. The piers were put in place under the old structure, and a special feature of the work is that the superstructure was erected while the old swing bridge and its approaches (on the same center line) were in use, the river being also open to navigation. This was effected by erecting the new superstructure in an inclined position, as shown in Fig. 1, and omitting the track stringers and floor system of the end panels, so as to allow trains to pass through the heel of the structure. At the left of this view is the swing span in its open position on the west side of the river, and at the right (projecting under the shore end of the new structure) is the east approach of the swing span.

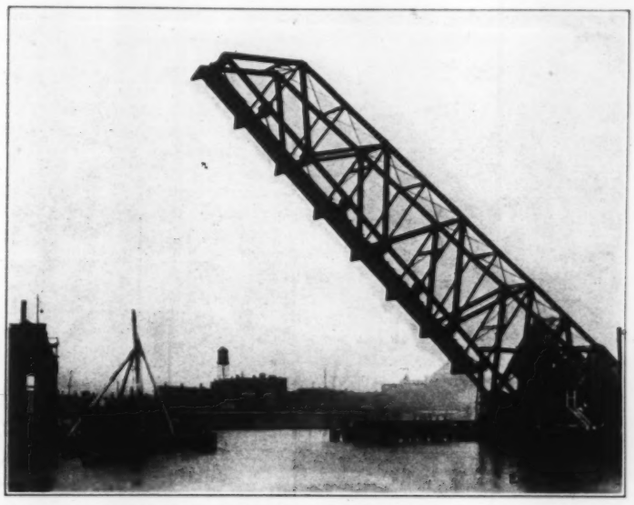


FIG. 1. BASCULE BRIDGE FOR THE BALTIMORE & OHIO RY. AT CLEVELAND, O.
Scherzer Rolling Lift Bridge Co., Chicago.
(The view shows the position in which the bridge was erected.)

Another special feature of the bridge is the arrangement of its operating mechanism. In most of the Scherzer bridges an operating strut pivoted to the truss has a rack which rides on an operating pinion driven by the machinery installed on the pier. By the revolution of this pinion the bridge is pulled up or pushed down. In the Cleveland bridge, the operating pinion is carried by the moving structure and gears with a horizontal stationary rack on a tower erected upon the piers at the heel end of the bridge. This is shown in Fig. 2. The axis of the pinion is, of course located in that part of the truss which has merely a horizontal travel in the combined rolling and vertical swinging movement of the bridge. The operating machinery is driven by two alternating-current electric motors of 75 HP. each, equipped with solenoid brakes operated by an independent switch in the operator's house. This house contains the controller, and has indicators to show the positions of the bridge and the end latch. At each end of the bridge are signals interlocked with derailing switches and with the end latch and main operating controller, so that the bridge cannot be operated until the signals have been set at the "stop" position and the derails opened.

The bridge was built under the direction of Mr. J. E. Greiner, M. Am. Soc. C. E., Assistant Chief Engineer of the Baltimore & Ohio Ry., and the design was prepared under the railway company's specifications. The substructure was designed and built by the railway company. The design of the superstructure, with its operating machinery and electrical equipment, was prepared by the Scherzer Rolling-Lift Bridge Co., of Chicago, which also maintained a supervision over the construction and erection. The steel work was built by the King Bridge Co., of Cleveland, Ohio, and was erected by the Pittsburg Construction Co., of Pittsburg, Pa.

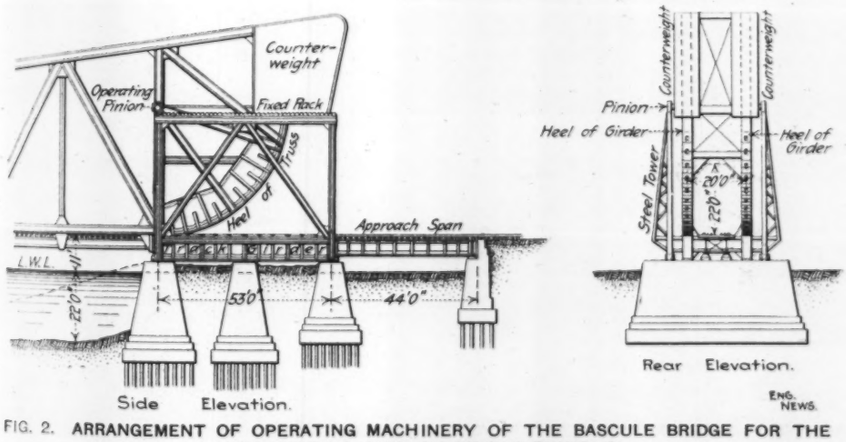


FIG. 2. ARRANGEMENT OF OPERATING MACHINERY OF THE BASCULE BRIDGE FOR THE BALTIMORE & OHIO RY. AT CLEVELAND, O.

PROGRESS ON THE NEW WATER-WORKS AND Sewerage System for New Orleans, La., may be summarized as follows, from information recently sent by request to this journal: "The Sewerage and Water Board is now laying water mains throughout the city, and expects to have 450 miles of pipe ready for service by the end of the present year, as well as the pumping and purification plant. The pipe mileage mentioned will cover the entire built-up area of the city. About 170 miles of mains have already been laid and the fire hydrants set thereon. A few miles of the new pipe system are now being supplied with water for fire protection by the New Orleans Water-Works Co. The company just named declined an offer made by the board for such portions of its works as the board thought would be useful to the city, whereupon the board proceeded with the construction of a complete distribution system. The board has acquired some nine miles of pipe and a stand-pipe in the Algiers section of the city, lying on the west bank of the Mississippi River. The Algiers system was built by the company about 1895. It will be supplied by the new pumping plant and purification works already mentioned as under construction. The new sewerage system built by the board has been in operation for over a year. There are now in service about 270 miles of sewers, with three high-lift pumping stations discharging through a force main directly into the Mississippi River, and two intermediate low-lift stations and four first low-lift stations. The six stations last named are provided with automatically operated pumps. Thus far only short lengths of sewers are being served by the four first low-lift stations. The total number of sewer connections at present is only about 1,100, the sewer connections thus far being optional. "Probably 75% of premises in the built-up portion of the city," we are informed, cannot reach a water main and consequently cannot install water closets with any reliable supply of water for flushing them. Mr. George G. Earl, M. Am. Soc. C. E., is General Superintendent of the Sewerage and Water Board of New Orleans, and to him we are indebted for this information.

BUILDING A RAILWAY EMBANKMENT BY THE HYDRAULIC METHOD.

By GEO. H. MOORE,* Assoc. Am. Inst. E. E.

The Chicago, Milwaukee & St. Paul Ry., in building its line through the Cascade Mountains in Washington, has encountered formidable difficulties. In making the maximum allowable grade and curvature 1.74% and 10°, respectively, necessarily much expensive construction has resulted on this particular part of the line. For example, it is said that one mile of roadbed at a certain point some eight miles from North Bend, Wash., will cost about $300,000. These troubles arise largely from the rugged topography of the mountains and the heavy timber. In clearing the large lateral areas, necessary for the high embankments, removing the giant trees becomes an item of very heavy expense. At Smyth's Camp, near North Bend, a right-of-way 700 ft. wide at the maximum point had to be cut through the virgin forest, and although clearing was started about April, 1907, the work of blasting and burning out the stumps was not completed until the middle of November.

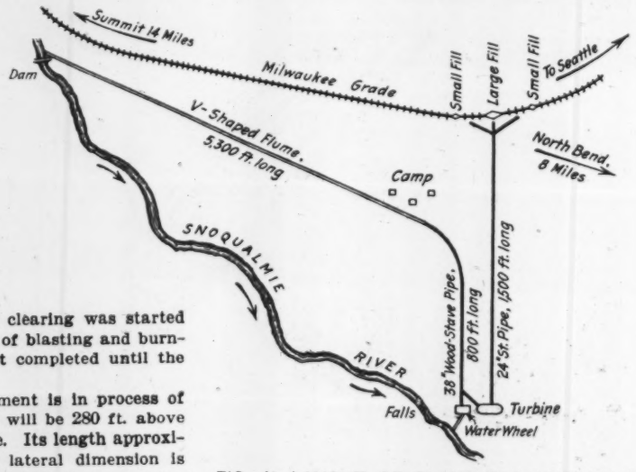


FIG. 1. LAYOUT OF PLANT FOR HYDRAULIC FILLING; CHICAGO, MILWAUKEE & ST. PAUL RY., NORTH BEND, WASH.

At this point an embankment is in process of construction whose roadbed will be 280 ft. above the elevation of its outer toe. Its length approximates 900 ft., its greatest lateral dimension is 706 ft., and its volume is stated by the contractor in charge to be about 750,000 cu. yds. It is claimed to be the largest railway embankment in the world. This claim, however, must be taken as referring to the extreme height of the fill, rather than to its volume. The question arises as to why a steel viaduct could not be thrown across the gulch. This was considered, although with a span of 900 ft. and a height of 280 ft. the problem is not easy of solution. It was found impossible to secure the necessary foundations, as the whole site is sand and gravel. No rock was struck in sinking several test pits and holes. The gravel of the adjacent hillsides, however, lends itself readily to the hydraulic method of working. A concrete culvert 706 ft. long will carry under this embankment the waters of a small stream.

The plant for furnishing water at the proper pressure may be divided into several parts: (1) a rock-filled dam; (2) a 5,300-ft. flume; (3) a 38-in. wood stave pipe, 800 ft. long leading from the flume end; (4) a 1,500-HP. impulse wheel turbine pump set; (5) a 24-in. steel delivery pipe from pump to fill. The relative disposition of the parts of this plant are shown in the accompanying sketch. It is interesting to note that all the water used for the excavating and filling is led down to the pumping plant and then raised over nearly the same route for some distance, as indicated in the sketch. This is necessary, however, as the nozzles are some 200 ft. above the end of the flume and as a pressure of 90 lbs. must be provided at the nozzles. With the pumping set located as shown, the total equivalent lift is about 800 ft.

The water is diverted from the south fork of the Snoqualmie River at a point almost exactly a mile above the beautiful Upper Falls. Here the river has cut a way through solid rock, and it became an easy matter to construct a rough dam across the channel.

The water is conveyed to the penstock through 5,300 ft. of V-shaped timber flume 6 ft. on a side. There is a uniform grade of 0.3% from headgate to penstock, giving a difference in elevation of about 16 ft. The flume is sustained on pole trestles for the most part, some of these over the deeper gulches being 40 to 50 ft. in height.

The flume terminates in a penstock from which a 38-in. wood stave pipe drops sharply down hill to the pump. This pipe is made up of 2 × 6-in. planking in lengths up to 15 ft., which was planed to correct sections for the circle at a sawmill some two miles below the camp. At the ends of each plank a saw cut was made edgewise to allow of inserting a thin steel plate to make the joints watertight. The planking was built into circular form on the ground and bound together by ¼-in. iron rods bent to a circular shape and equipped with screw tighteners. Owing to the sharp descent which this pipe makes, steel bands are fastened at frequent intervals and these are guyed to nearby trees with steel cable. The pipe follows the ground surface, very little attempt at grading having been done. The steel banding varies in spacing from about 10 ins. at the top to about 1½ ins. at the bottom. The pipe is 800 ft. long and drops approximately 400 ft. in that distance.

The wood pipe line ends in a heavy concrete walled chamber where the water divides for the turbine supply and for the impulse wheel. The turbine takes its water at 175 lbs. initial pressure through a 24-in. steel pipe. This pressure removes all chance of turbine suction troubles. The water-wheel set is very simple and small,

Fig. 2. View of Pumping Unit of Hydraulic Filling Plant.

occupying a space of something like 6 × 15 ft. The turbine is driven by a group of four impulse wheels mounted on one shaft. Each wheel is 36 ins. in diameter and has 16 cast buckets. There is no hood or casing other than a simple timber box built over the wheels to protect the operator from the spray. Each wheel is fed by a 2½-in. brass double nozzle controlled by a hand wheel gate valve. There is no governor. The water-wheel is direct connected to the turbine pump by a flexible flange coupling in which the driving stress is carried by four [illegible] of leather belting. Each link is made up of 16 thicknesses of ¼-in. stock. The turbine itself is a special Worthington four-stage design taking water at 175 lbs. pressure and delivering it at 350 lbs. The steel casing is reinforced by heavy ribs on the casting.

The turbine delivers water to an 18-in. discharge which changes at the concrete buttress to a 24-in. steel pipe. This pipe is lap riveted, built in 6-ft. sections and assembled for handling, in 30-ft. sections. The line is [illegible] ft. long and rises 600 ft. above the turbine. The steel plate is ⅝-in. at the lower end of the line and ⅜-in. at the nozzle end.

The contractor for this work, Mr. Sidney Smyth, expects to be able to move an average of 10,000 cu. yds. per 24 hrs. and to reach a figure of 30,000 cu. yds. under the most favorable conditions. All the material to be moved is contained in the right-of-way adjacent to the fills. The contract price is 15 cts. per cu. yd.

*Terry Ave., Seattle, Wash.

THE CHICAGO GARBAGE REDUCTION PLANT.

By EMMONS J. ALDEN.*

Since Nov. 1, 1906, a large proportion of the garbage of Chicago has been treated in a reduction plant, built and operated by the Chicago Reduction Company.

Prior to that date the urgent necessity of a sanitary method of disposing of garbage, animal and vegetable waste, separated from other matter, had long been keenly felt. Chicago had the unenviable reputation of being the only city of importance using the primitive dump for its disposal. After many years of careful investigation on the part of the members of the city council and city officials, a contract was awarded for the present system, the city still continuing to collect the garbage.

The reduction plant is located at 39th and Iron Sts., a distance of 4¾ miles to the southwest of the center of the city. It has a frontage of 380 ft. on the Chicago River. A side-track from the Chicago Junction Railway (belt line) enters its grounds. By laying a short distance of track it will become accessible also by the street car lines of the city. This furnishes transportation facilities by water, railway, street car or vehicle, which are unsurpassed.

The grounds cover 3½ acres, the buildings occupying about two-thirds of this space. The plant comprises the following:

(1) A dock, 120 ft. long by 80 ft. wide, about 20 ft. above the river level.
(2) A receiving building, 70 × 80 ft. in plan, two stories high.
(3) A drier building, 80 × 80 ft., two stories high.
(4) A naphtha extraction building, 38 × 65 ft., four stories high.
(5) A naphtha storage building, 25 × 30 ft., a sub-basement.
(6) A milling building, 20 × 40 ft., three stories high.
(7) A boiler house, 40 × 46 ft., two stories high.
(8) Shops, 25 × 120 ft., one story high.
(9) An office, 20 × 20 ft., one story high, with a sub-basement.

The principal buildings are of modern and permanent construction, being built of brick and reinforced concrete throughout, making them fireproof and sanitary. They are so designed as to furnish ample light by day, and are generously equipped with electric light for night labor. They form a complete series from start to finish of process and are built with intermediate spaces so that each building may be duplicated and the capacity of the plant doubled, if required. The present capacity provides for 500 tons of garbage daily. The motive power is electricity, each apparatus being equipped with a separate electric motor. The power is furnished by the Edison Co., of Chicago.

The garbage is carted to the receiving stations along the river in removable steel boxes. The boxes are loaded by derricks upon scows and shipped to the plant. (See Fig. 1.) Where the districts are in close proximity, the garbage is carted direct. In the future the boxes may be

*Ward Superintendent (Department of Public Works, Bureau of Streets), 204 Huron Street, Chicago, Ill.

conveyed by steam railway or by electric street cars from the outlying territory.

The dock (Fig. 2) is the receiving platform. This has a concrete foundation, over which is laid a vitrified brick pavement. On the dock are two boom derricks, each with a 55-ft. mast, operated by a three-drum engine. The boxes are hoisted from scow or wagon by derrick and their contents are then dumped into connected double hoppers. These are built of concrete, have a capacity of 75 tons each, and are located just outside the receiving building. After the boxes are emptied they are swung back, cleansed and sterilized in a large, deep steel vat.

Large bucket elevators convey the garbage from the hoppers to the upper floor of the receiving building and deposit it on conveyors, from which all foreign material is eliminated by hand picking. The garbage then passes through crushing machines, after which the material is carried by a series of conveyors to the drying house and automatically discharged into hot air dryers. There are six of these, each 5½ ft. in diameter and 40 ft. long. These are revolving steel cylinders, to the interior of which are riveted angles to keep the material in motion as the drier shells revolve. Each drier has a capacity of 3½ to 4 tons of wet material per hour. The drives are heated by separate furnaces, which are equipped with blowers to create a blast, and have self-feeding coal hoppers and underfed stokers. In passing through the driers the moisture of the material is eliminated to the extent of 75% or more.

The gases from the driers are disposed of by a series of fans and discharged into a concrete stack 6 ft. in diameter, 150 ft. high. This contains a sprinkling system for the purpose of furnishing moisture. The fans force the vapors through this sprinkling system, where for the most part the odors are absorbed and carried to the river. The remaining vapors are carried off in the upper currents of air, being small in quantity and volatile.

The material from the driers continuously drops on a conveyor and is carried to the naphtha-extraction building, which contains six percolating tanks (Figs. 3 and 4). These are 8 ft. in diameter and 16 ft. high. The dry material is confined in the percolating tanks and treated with gasoline, which separates the grease from it, the gasoline and grease being carried to separators in which the grease is separated from the gasoline and the gasoline returned to its storage tank. The process is continuous, the gasoline being used over and over again, only about 2% by weight being lost during each process. The garbage or "tankage," as it is now termed, is conveyed to the mill house. There it passes through four screens, each 4 ft. in diameter and 12 ft. long, of varying mesh for the different stages of the process. The tankage is then discharged into two 48-in. Stedman disintegrators, after which the screened and ground material is carried by conveyors to the scale house and weighed by an automatic scale, which also dumps it directly into cars for shipment. It now contains less than 10% of moisture and less than 1% of grease. The grease is put in storage tanks, weighed on tank scales and pumped into tank cars.

FIG. 1. CITY GARBAGE SHIPPING DOCK, CHICAGO AVENUE AND NORTH BRANCH OF CHICAGO RIVER, CHICAGO, ILL.

The boiler house contains two 253-HP. Sterling water-tube boilers. Overhead coal bunkers carry the coal to automatic stokers of the Swift pattern. The grate bars are of the Ajax rocking type. The shafting for the stokers also keeps the grate bars in continuous motion, the result being perfect combustion and consequently no smoke. Sullivan County, Indiana, 1¼-in. screenings are used for fuel. The steam is used in connection with the naphtha extraction process, to drive the pumps and the hoisting engines.

The naphtha storage consists of a large concrete vault in which are tanks with a capacity of 20,000 gals. of gasoline. The vault is covered with an iron roof, provided with openings on the sides to permit the free circulation of air to avoid the accumulation of gas.

The plant cost over $200,000, and is owned by a stock company known as The Chicago Reduction Co. Its officers are non-resident, with the exception of its secretary and general manager, Mr. Charles Turner. Mr. Turner has been engaged in the disposition of hotel and restaurant garbage of this city for the past fifteen years. Five years ago he invented a digester which performed three separate functions at one and the same time—that of cooking, pressing and drying of garbage—without exposure during the entire treatment. The process adopted by this company is the result of the experiments and experience of Mr. Turner, who built a small plant and operated it for some time before the present works were erected. It is what is known as the drying system. The garbage, after being freed from foreign material and crushed to a uniform size, is subjected to a temperature of about 800°. It is distinctive, being a combination of the features of other well-known systems, and the economy of handling and of operation is believed to be greater than that of any other plant in existence.

The by-products are grease and tankage. Garbage grease is of an oily nature, and after the glycerine and red oils have been extracted it is used in the manufacture of cheap grades of soaps and candles.

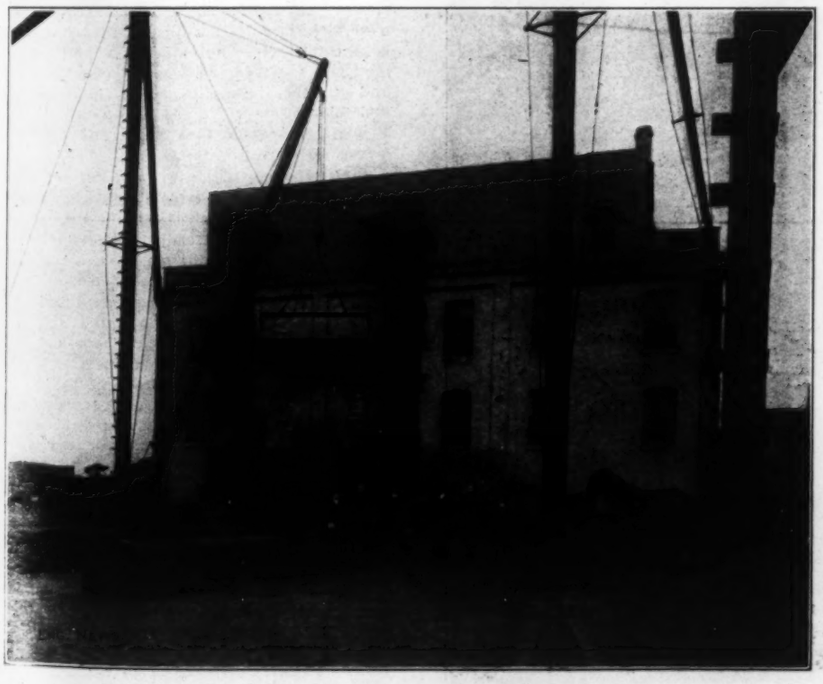


FIG. 2. GARBAGE RECEIVING DOCK OF THE CHICAGO REDUCTION CO.
(The garbage receiving hoppers and the bucket elevators may be seen at the base and extending up the wall of the building, respectively.)

The tankage, which is in the form of fine powder or dust, is sold to jobbers for a filler or base in compounding fertilizers. A larger percentage of grease is secured by the naphtha process, and the fertilizer base rendered of greater commercial value by reason of the grease being more fully eliminated than is possible with other methods.

The sanitary aspect both of the plant and the method of collection and delivery is deserving of especial consideration. The process is automatic as far as is possible. The floors are of concrete and water connections are amply supplied for cleansing purposes. The garbage is collected and delivered daily at the plant, where it is promptly disposed of. The plant is located north of and immediately adjoining the Chicago packing house district. From the experiences of other cities with reduction plants this seems a desirable feature, for although odors peculiar to the reduction process are believed to be so disposed at this plant as not to be perceptible, yet should they escape they could not be distinguished from the various odors emanating from the stock yards region.

The contract between the city and the Chicago Reduction Co. was executed on Aug. 31, 1906, and went into effect on Nov. 1, 1906. It provides, among other requirements, for the final disposition of the garbage of the city of Chicago for a period of five years; that the city shall deliver to the contractor all garbage collected in the city; that all deliveries of garbage shall be made free of cost to contractor at its plant; that delivery of garbage shall be made in metal boxes, so constructed that they may be hoisted by a crane and their contents dumped by overturning; that before being returned to the city the boxes shall be sterilized, at the expense of the contractor; that garbage must be disposed of by reduction, etc.; that the contractor shall receive the sum of $47,500 per year, for each of the five years, provided his work be performed in strict compliance with the specifications of the contract; that the city shall have the right, at the expiration of the contract period, to purchase plant used by the contractor in the performance of its contract, the manner of fixing the price being stipulated.

For the purpose of delivery the city has provided and owns 210 two-horse wagons, with racks, and 600 4-yd., water-tight, removable steel boxes. The boxes have six sectional iron cover lids, thereby concealing two-thirds or more of the contents during loading.

FIG. 3. TOP VIEW OF PERCOLATING TANKS, CHICAGO REDUCTION PLANT.

Three docks have been located along the north and south branches of the Chicago River for receiving and shipping purposes. The one fully completed and in operation (Fig. 1) is situated on the north branch of the Chicago River, at Chicago Ave., and consists of a planked, broad roadway with a 50-ft. boom derrick to shift the boxes from the wagons to the scows for shipment and replace the empty boxes on the wagons. The city has, by contract, the use of three scows, one being with power and serving the double purpose of (1) a scow and (2) a tow for the others. The contractor receives $50 per day for the use of the scows.

Mr. M. J. Doherty, Superintendent of Streets of Chicago, with the aid of his ward superintendents, during the past year has secured thorough separation of garbage from other refuse on the part of the citizens, attended to plans, specifications, progress and fulfillment of contracts in the matter of necessary equipment, and successfully inaugurated the present system of collection and delivery.

Previous to this contract all household refuse, including garbage, ashes and rubbish, had been collected in mixed condition. The teams employed by the city were hired from individuals, the wagons being of 6-yd. capacity and of a specified form and appearance. The refuse was carted to clay pits, located in the outlying portions of the city. These holes, resulting from brick-making, were about 70 ft. in depth, and generally from two to five miles from the point of collection.

On adopting the reduction system it became necessary to separate the garbage from the other refuse. To effect this, card notices were distributed to householders notifying them to put garbage (table refuse only) in galvanized cans of a size not to exceed the capacity of 8 gals.; ashes and all other refuse, including tin cans, bottles and rags, in cans of a size not to exceed 30 gals. Request was made that paper and combustible refuse be burned.

Chicago comprises an area of 191 sq. mi., has over 4,000 miles of streets and alleys, and is divided into 35 wards. Under the general supervision of the superintendent of streets, a ward superintendent is in charge of street and alley cleaning, repairs and refuse removal in each ward. The separation notices were distributed by police officers under direction of the ward superintendents, two officers having been assigned to each ward. A consulting engineer in a recent work on refuse disposal states that "If once combined, it is practically impossible to effect subsequent separation." It seems creditable, therefore, that not over 3% of foreign matter is found in Chicago's collection.

About 300 tons of garbage are delivered at the reduction plant daily, Sundays excepted, while about 25 tons daily in the remote districts are still being disposed of in distant dumps. This is entirely household garbage, collected by the city. Hotel, restaurant, boarding house, commission and market garbage is collected by private contractors. This is dumped in mixed condition in the clay pits with exception of hotel swill, so-called, which is disposed of to rendering plants. All contractors thus employed have been notified that, commencing with 1908, disposal of garbage

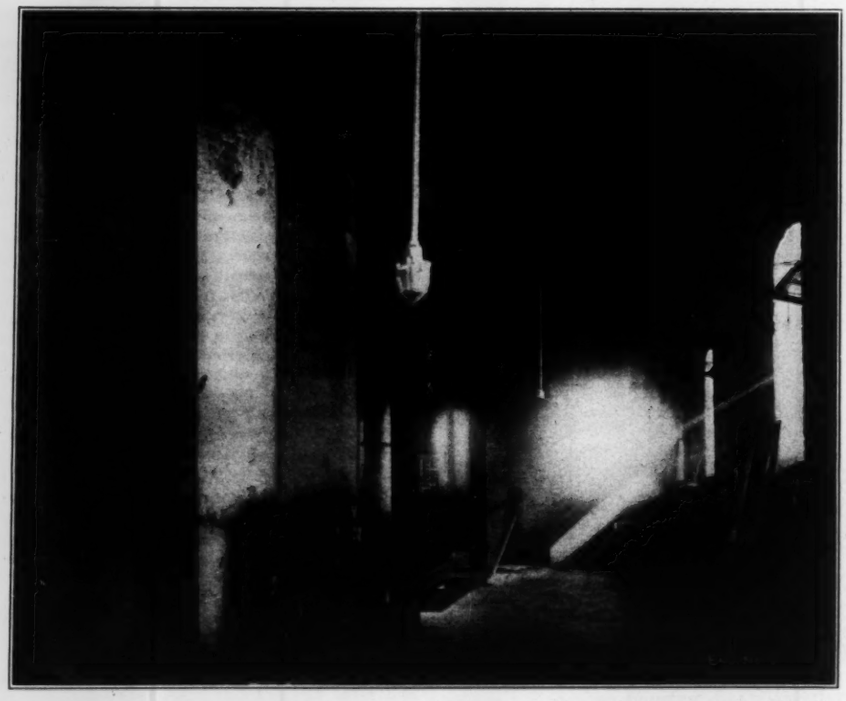


FIG. 4. VIEW OF PERCOLATING TANKS FROM BELOW, CHICAGO REDUCTION WORKS.

in all dumps will be prohibited. Eventually it is expected that the reduction plant will care for the city's entire output of garbage, but it is not anticipated that the city will make the collections now made by private contractors.

THE STANDARD SPECIFICATIONS FOR TELEPHONE LINES OF THE UNITED STATES RECLAMATION SERVICE.

In view of the number of telephone lines, built by the U. S. Reclamation Service in connection with the various irrigation works which it has constructed, it has been found advisable to prepare specifications outlining the proper construction of such lines. We are able to reprint these through the courtesy of Mr. F. H. Newell, M. Am. Soc. C. E., Director of the Reclamation Service.

NOTE ON THE USE OF SPECIFICATIONS.—In compiling specifications from these standard paragraphs care should be exercised to make required insertions and modifications in the paragraphs used, to strike out superfluous paragraphs and to add other necessary paragraphs.

For short telephone lines serving a small number of stations a ground return circuit will in general give satisfactory service. For long lines or those having many stations a metallic circuit will be preferable. In determining whether to use the ground circuit or metallic circuit the engineer should carefully study the importance of continuity of service, the length of line and number of stations, the liability of disturbance by existing or contemplated electrical systems and other local conditions. For the usual telephone systems of the Reclamation Service No. 12 wire as specified in Paragraph (l) will be amply large, but for lines subjected to exceptionally heavy loads of sleet and snow the use of No. 10 wire may be necessary.

STANDARD SPECIFICATION.

(a) POLE LINE.—The pole line will follow tangents and curves as shown in the drawings and will have the number of corners therein shown. An average of 30 poles per mile shall be used on tangents. The spans adjoining a pole on a curve at a corner shall not exceed 150 ft. each for a pull of 5 ft., and the allowable length of span shall decrease 10 ft. for each increase of 5 ft. in the pull up to and including a pull of 30 ft. When a bend made on a single pole produces a pull of more than 30 ft. the pole shall be thoroughly braced and guyed and the adjoining spans shall not exceed 100 ft. each, or such a bend shall be made on two poles and the lengths of the adjoining spans adjusted with the foregoing provisions relating to span and pull. The term "pull" as herein used means the perpendicular distance from the pole under consideration to a straight line joining the two adjacent poles. When a span of from 200 to 250 ft. is necessary, the adjoining spans shall not exceed 100 ft. each, and where a span of from 250 to 500 ft. is necessary, the adjoining two spans at each end shall not exceed 100 ft. each. On uneven ground the spans shall be so chosen and the poles so set as to avoid abrupt changes in the direction of the wire line vertically. In distributing poles, the heaviest shall be placed so far as practicable on corners and at the ends of long spans.

(b) POLES.—Telephone poles shall be in general 5-in. poles 25 ft. in length. At crossings of highways, railroads and gullies 6-in. poles of requisite length shall be used, and for this purpose ..... poles 30 ft. in length and ..... poles 35 ft. in length will be required. The poles shall be cut from growing red or white cedar trees, shall be reasonably well proportioned for their length and shall be peeled, neatly trimmed, well seasoned, reasonably sound and free from unsightly wind twists, injurious butt rot and other defects that materially impair them for the use intended. Butt rot in the center, including small ring rot outside of the center, the total of which does not exceed 10% of the area of the butt, will be permitted. Sweeps not exceeding 1 in. for every 5 ft. in length of pole will be permitted. The tops of seasoned 5-in. poles shall measure not less than 15 ins. in circumference and those of 6-in. poles not less than 18 ins. If the poles are measured when green 5-in. poles shall be not less than 16 ins. in circumference at the tops and 6-in. poles not less than 19½ ins. The top of each pole shall be trimmed so as to form a right-angled roof.

(c) PAINTING.—The roofs of poles shall be painted with two coats of the best quality of iron oxide paint.

(d) SETTING POLES.—On tangents the poles shall be set in a vertical position, and on curves and at corners they shall be raked 10 ins. for a pull less than 5 ft. 15 ins. for a pull of from 5 to 10 ft. and 25 ins. for a pull of more than 10 ft. Each pole hole in earth shall be 5 ft. in depth and shall be dug of sufficient size throughout to admit of tamping around the entire perimeter of the pole. On hillsides the depth of the holes shall be measured from the lowest side of the opening. Where the line crosses solid rock, pole holes shall be blasted to a depth of 3 ft., unless such solid rock can be covered by a single span not exceeding 250 ft. Each pole shall be carefully held in proper position while the hole is being filled. Filling holes with earth shall be done by one man and the earth firmly tamped simultaneously by three men. Rock debris when used for filling holes shall contain sufficient earth to fill all cavities therein and shall be homogeneously placed and thoroughly compacted. When the hole is filled, earth or rock shall be piled and firmly packed about the hole to a height of 1 ft. above the original ground surface. The filling for holes and the general manner of setting poles shall be such as will enable each pole to withstand the strains to which it will be subjected.

(e) BRACES.—Braces shall be 5 ins. in diameter at the top, shall be long enough to attach to the pole at two-thirds the height thereof above the ground, to make an angle of 30° therewith and to extend into the ground at least 4 ft. measured along the brace and shall conform in all other respects to the specifications for poles ..... braces ..... feet in length, ... braces ..... feet in length and ..... braces ..... feet in length will be required.

(f) SETTING BRACES.—Each brace shall be set in the ground at least 3½ ft. in vertical depth. The brace shall be cut slanting at the top to fit close to the pole and shall be attached to the pole with a ⅝-in. bolt supplied with a washer at each end. This bolt shall be placed at the lowest point of the joint. In fitting the brace to the pole all trimming shall be done on the brace.

(g) GUYS AND ANCHORS.—Guys shall consist of No. 6 B. W. G., galvanized steel wire. Guy anchors in earth shall consist of galvanized cast-iron plates and galvanized iron rods. Each cast-iron plate shall be 8 ins. square and ½-in. thick and shall be provided on the lower face with a cylindrical lug at the center having a diameter of 2 ins. and a height of 1½ ins. and with diagonal ribs ½-in. thick rising from zero elevation at the corners and terminating in the cylindrical lug with elevation equal thereto. Each cast-iron plate shall have a ¾-in. cored hole through its center for the reception of the anchor rod. Each galvanized iron rod shall be ⅝-in. in diameter and 6 ft. in length and shall be provided at the upper end with a suitable eye and a wire rope thimble for a ¼-in. rope and at the lower end with U. S. standard threads and a galvanized iron nut. Guy anchors in rock shall consist of galvanized iron rods of the combination eye and wedge-bolt type 1 in. in diameter and 18 ins. in length, each provided with a suitable wedge and a wire rope thimble for a ¼-in. rope.

(h) PLACING GUYS AND ANCHORS.—Each guy shall be attached to the pole immediately below the bracket by making two turns around the pole and wrapping the end eight times around the guy and shall be secured to its rod by passing around the thimble and terminating on itself in eight turns. The turns about the pole shall be secured by at least three 2-in. galvanized-iron staples. The angle between the guy and its pole shall be as nearly 45° as is practicable. Anchors in rock shall be securely fastened in holes so drilled therein as to give the anchors the greatest possible efficiency. Holes for anchor plates shall be dug at least 3½ ft. in vertical depth.

(i) GUYING AND BRACING.—Guys and braces shall be placed wherever considered essential by the engineer. On tangents and on curves having pulls less than 10 ft. double side guys will be required about every 1,000 ft. of line; and on curves or at corners where the pull is from 10 to 30 ft. each pole shall be provided with a guy or brace. On curves and at corners each pole at which the pull exceeds 30 ft. shall be provided with either a guy or a brace placed in the plane of each of the adjoining spans and the adjacent poles shall be provided with appropriate supplemental bracing or guying. At least one head and one back guy shall be installed on every mile of line. Additional head and back guys or braces shall be used wherever the slope of the ground, length of span, change in direction or extra pole height at road crossings requires them for stability.

(j) BRACKETS (GROUND CIRCUIT).—Pony telephone side brackets 1½ × 2 × 10 ins. shall be used. They shall be made of the best quality of well-seasoned, sound, straight-grained oak, free from knots and sapwood, shall have the insulator threads truly cut and complete and shall be painted with two coats of the best quality of iron oxide paint. Each bracket shall be securely fastened to the pole with one 40d and one 60d galvanized wire nail in such a position that the base of the bracket will be about 14 ins. below the top of the pole. Where the change in the direction of the wire at any pole is more than 60° an extra bracket shall be used. Brackets shall be placed on the same side of all poles except on curves or at corners, where they shall be so placed that the stresses produced by the wires will tend to press the insulators toward the poles.

(j) BRACKETS (METALLIC CIRCUIT).—Pony telephone side brackets 1½ × 2 × 10 ins. shall be used. They shall be made of the best quality of well-seasoned, sound, straight-grained oak, free from knots and sapwood, shall have the insulator threads truly cut and complete and shall be painted with two coats of the best quality of iron oxide paint. Each bracket shall be securely fastened to the pole with one 40d and one 60d galvanized wire nail. Where the change in direction of the wire at any pole is more than 60° an extra bracket shall be used for each wire. On tangents the brackets shall be placed one on each side of the pole and on curves and corners they shall be so placed that the stresses produced by the wires will tend to press the insulators toward the poles. The top bracket shall be so placed that its base will be about 14 ins. below the top of the pole, and the bottom bracket so that its base will be 12 ins. below that of the top bracket, except on transposition poles on tangents. On transposition poles on tangents the brackets shall be at the same elevation so placed that the insulator for each wire will be as nearly as practicable on a straight line between those for the same wire on the adjacent poles. On transposition poles on curves the bracket shall be so placed that the transposition insulator will be as nearly as practicable on a straight line between the insulators for each wire on the adjacent poles.

(k) INSULATORS (GROUND CIRCUIT).—Standard pony, glass, 10-oz. insulators shall be used. They shall be made of common glass, shall be free from cracks, blow-holes, flaws and sharp edges and shall have smooth threads of uniform pitch accurately fitting the threads on the brackets.

(k) INSULATORS (METALLIC CIRCUIT).—Standard pony, glass, 10-oz. insulators and two-piece transposition insulators of equivalent strength shall be used. They shall be made of common glass, shall be free from cracks, blow-holes, flaws and sharp edges and shall have smooth threads of uniform pitch accurately fitting the threads on the brackets.

(l) LINE WIRE.—The line wire shall consist of No. 12, B. W. G., galvanized-iron wire of the quality known as "Best Best," having an average resistance at 68° F. not to exceed 33½ ohms per mile. The wire shall be of uniform cross section, shall weigh approximately 165 lbs. per mile, shall have an ultimate tensile strength of not less than 545 lbs. and shall be capable of withstanding at least 15 twists about its axis in a length of 6 ins. It shall be soft and pliable and capable of elongating 15% without breaking, after being galvanized. The diameter of the line wire in inches shall be not more than 0.113 nor less than 0.106 in. The wire shall be furnished in coils of one-half mile or one mile continuous lengths, without welds, joints or splices, and each coil shall be drawn from a rod without welds, joints or splices of any kind. The galvanizing shall consist of a coating of zinc evenly and uniformly applied in such a manner that it will adhere firmly to the surface of the iron. The galvanizing shall be of such quality that clean dry samples of the galvanized wire shall appear black when they are four times alternately immersed for one minute in a saturated copper sulphate solution and then immediately washed in water and thoroughly dried.

(m) STRINGING WIRE.—The wire shall be strung with as few joints as possible and shall be joined by twisting the wires for a distance of about 8 ins. around each other two complete turns and soldering, the end of each wire terminating in five tightly fitting contiguous turns around the other wire. The line wire shall be tied to the insulators with tie wires of No. 12, B. W. G., galvanized-iron wire cut in suitable lengths. The line wire shall first be laid in the groove of the insulator on the side away from the pole, after which the tie wire shall be past entirely around the insulator and line wire and terminate at each end in five tightly fitting turns around the line wire. The tension on the line wire for each span shall be in the judgment of the engineer as high as will be safe for the minimum temperature for the locality.

(n) TRANSPOSITION (METALLIC CIRCUIT).—In general a transposition of the line wires shall be made once in each mile, but the exact number and location of transpositions shall conform to the local requirements therefor. On tangents each transposition shall be made without the use of transposition insulators by interchanging the wires laterally in one span and vertically in the two succeeding spans. On curves each transposition shall be made by the use of a transposition insulator.

(o) TRIMMING TREES.—All trees along the line of such character and location as to render them liable to being blown over so as to interfere with the telephone wires shall be cut down and removed or burned, and all trees close to the line that in the judgment of the engineer will not endanger the telephone wires shall be so trimmed as to leave a clear space of 10 ft. about telephone wires in all directions under stress of the heaviest probable wind storms.

(p) LIGHTNING RODS.—Lightning rods consisting of No. 12, B. W. G., galvanized-iron wire shall be installed throughout the line at intervals of about one-third mile. Each rod shall be located about one-fourth the distance around the pole from the bracket and shall be attached to the pole with 2-in. galvanized-iron staples. The upper end of each rod shall project about 3 ins. above the top of the pole and the lower end shall terminate beneath the butt of the pole in a flat coil containing about 6 ft. of wire.

(q) LIGHTNING ARRESTERS.—A lighting arrester shall be installed on each line pole at which the current is transferred from the line wire to a station wire. The arrester shall be of the double-pole, lightning and sneak-current type, shall have adjustable and removable carbon blocks mounted upon porcelain bases and shall have fuses that will adequately protect it from lightning and sneak currents. The arresters shall be connected with No. 12, B. W. G., galvanized iron wire to any existing water pipe system near by or to a galvanized iron ground rod ½-in. in diameter and 6 ft. in length driven into permanently moist earth. The connecting wire shall be carefully soldered to the water pipe or to the ground rod. Twenty-five extra sets of fuses shall be furnished with each arrester.

(r) STATION WIRING (GROUND CIRCUIT).—The current shall be carried into buildings on No. 18, B. & S. G., rubber-insulated copper wire covered with black braid saturated with waterproof compound and carried on porcelain knots having a diameter of not less than 1½ ins. The return pole of each instrument shall be connected by means of a similar wire to any existing water pipe system nearby or to a galvanized iron ground rod ½-in. in diameter and 6 ft. in length, driven into permanently moist earth. The connecting wire shall be carefully soldered to the water pipe or to the ground rod. Inside wiring shall consist of No. 18, B. & S. G., rubber-insulated copper wire covered with braid of a greenish color. All inside wiring shall conform to the best practice and shall be done only by expert electricians. Where wires pass through walls and partitions insulated bushing shall be provided.

(r) STATION WIRING (METALLIC CIRCUIT).—The current shall be carried into and out of buildings on No. 18, B. & S. G., rubber-insulated copper wire covered with black braid saturated with weather-proof compound and carried on porcelain knobs having a diameter of not less than 1½ ins. Inside wiring shall consist of No. 18, B. & S. G., rubber-insulated copper wire covered with braid of a greenish color. All inside wiring shall conform to the best practice and shall be done only by expert electricians. Where wires pass through walls and partitions insulated bushings shall be provided.

(s) INSTRUMENTS.—The telephones shall be of the long-distance bridging type, each comprising a granular carbon transmitter, a two-cell battery, a bi-polar hand receiver, a hook switch, a ringer of 2,000 ohms resistance and a magneto generator capable of easily operating at one time all of the ringers on the line. There will be required ..... telephones of the wall type and ..... of the desk type. Each proposal shall be accompanied by a complete description of the various essential parts of the telephone that the bidder proposes to furnish.

MARKING RAILS TO INDICATE THEIR RELATION TO THE ORIGINAL INGOT.

One of the important points of the rail specifications recently recommended by the American Railway Association is that the rails should be branded or marked in such a way that every rail will show from what part of the ingot it was rolled. This practice has been in force on the Philadelphia & Reading Ry. since 1901, the rail from the top of the ingot being marked A, the next B, and so on to E. In a letter to the "Railway Age," by Mr. J. Bertram Young, chemist of the railway company, it is stated that over 60% of the rails which fail in the tracks are those from the top of the ingot; the next largest percentage of failure is represented by the "E" rails, or those from the bottom of the ingot. The same practice has now been included by the Pennsylvania R. R. in its recent specifications for rails amounting to 55,000 tons for delivery during 1908. These specifications, however, are only tentative, as the railway company is investigating the matter and has not yet definitely adopted a standard form of specifications. For several years past railway engineers have endeavored to enforce their demands for rails of better quality, but with little success until dur-

ing the past year. Several engineers have favored a fixed discard of about 25% from the head of the ingot. This has been objected to by engineers as being perhaps insufficient in some cases, while the rail making companies have protested that it would be excessive and entirely unnecessary. It is understood that with the introduction of branding the rails by position, the failure of the A rail under the drop-test would result in the rejection of all the A rails from that heat of steel. It thus puts the acceptance or rejection upon the quality of the rail and leaves the manufacturers to make such discard as they may think proper. A statement given out by the Pennsylvania R. R. in regard to its recent order under the new trial specifications is in part as follows:

The railway company recognizes that it is a purchaser, not a manufacturer. Considerable latitude is, therefore, to be allowed in the methods of manufacture, so long as the result is a sound rail. The company has devised tests of a character so exacting that it is made very much to the interest of the manufacturers to discard all material of the soundness of which there is any doubt. The new specifications also provide that rails shall be free from injurious mechanical defects and flaws, differing from the old specifications in that no attempt has been made to describe the particular defects or flaws that will cause the rejection of rails. It is not considered wise to attempt to classify in the specifications the relative importance of defects, but it is specified that no rails will be accepted that contain defects or flaws which in any way impair their strength. To still further strengthen the practice of the company and to insure that whatever future changes are made shall be based upon accurate data, a system has been devised whereby the history of all rails purchased will be fully recorded. In order that it may be possible to identify the part of the ingot from which particular rails were made, the new specifications require that (in addition to the usual marking) a letter shall be stamped on each rail to indicate its position in the ingot. To compile and consider the experience with rails, a special committee is to keep in touch with the art, and is expected to supply the company with data that will enable it to secure the best rails which, at the time of any order, it is possible to manufacture. In placing its orders the Pennsylvania R. R. invites the manufacturers to undertake to fill part of the allotment with rails made by the open-hearth process. It is desired to ascertain more clearly the actual differences in service as between the open-hearth and the Bessemer product.

STEEL TOWERS FOR HIGH TENSION TRANSMISSION.

In the accompanying figure there are shown the two side elevations of high tension transmission line towers which have been patented and are now being manufactured by the Receivers of Milliken Bros. (Inc.) at their shops at Milliken, Staten Island, for the use of the Great Western Power Co., of California. They are intended to carry two circuits of three wires each transmitting a current of 100,000 volts. The total line will be some 1,000 miles long and the towers will be placed for spans of 750 ft.

The towers are constructed, according to the dimensions and shapes shown in the figure, of galvanized structural steel shapes, angles in all members except the horizontal struts, which are channels. They are made in short pieces to facilitate transportation, in standard lengths, so as to be interchangeable and with bolted connections for ease in erection. For the galvanizing a new plant has been installed at the Staten Island shops by means of which pieces over 30 ft. in length may be dipped at one operation.

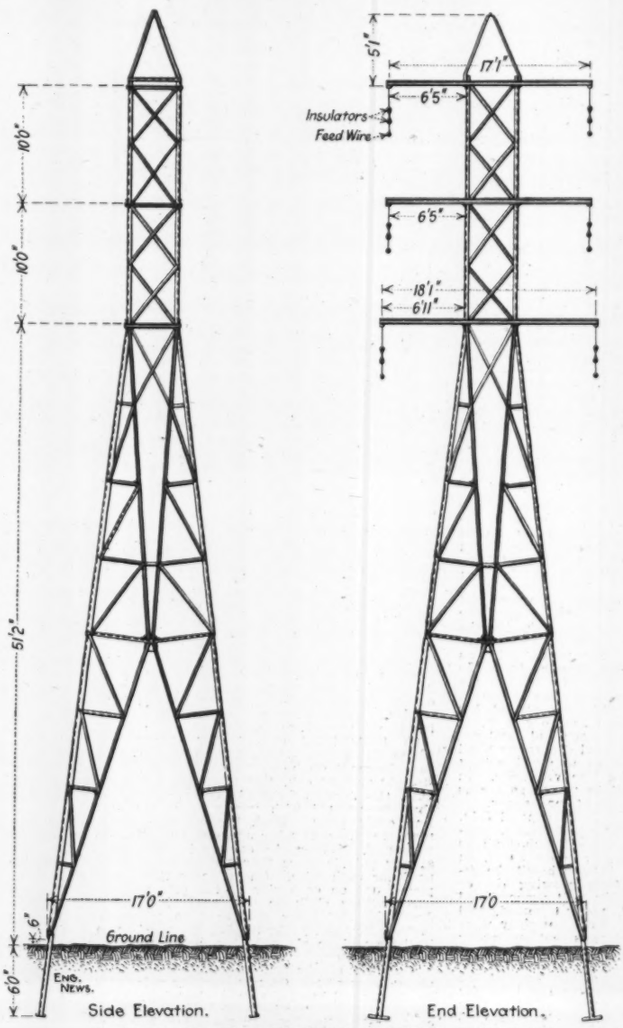
From the results of extensive full-size tests, both for deflection and for failure, it was decided to design the tower shown in the figure for simultaneous side pulls of 1,000 lbs. at the top and 2,500 lbs. at each of the three cross-arms, with a vertical load of 1,000 lbs. on the end of each of the six cross-arms and at the end of any one cross-arm a pull of 3,000 lbs. in the direction of the line. These tests also showed that with ordinary tamped earth foundations it is not necessary to use concrete bases in which to set the legs of the towers, although the probable effect of the earth in rusting the metal would make such practice desirable.

The drawings and information in this article have been given out by the Receivers for Milliken Bros.

LABOR COST OF LAYING VITRIFIED CLAY ELECTRIC CONDUIT.

By DEWITT C. WEBB,* M. Am. Soc. C. E.

The following table gives the labor cost of laying vitrified clay electric conduit at the U. S. Navy Yard, League Island, Pa., by day labor during the years 1904 and 1905. Laborers were paid $1.52 and $1.84 per day of eight hours. Leading men in charge of gangs were paid $2.08 per day and lines and grades were established by a subinspector at $4 per day. The subinspector also had general oversight of the work under the Civil Engineer in Charge. All conduits were laid carefully to line and grade, the grade being inclined downwards to manholes. Manholes were connected with sewers. Most of the conduit was of the four-way type in 3-ft. lengths. Joints were made with steel dowels and each joint was wound with a 9-in. wide strip of burlap which had been saturated with a hot mixture of coal tar, pitch and wax tailings. The conduits were protected from injury by being enclosed in 1:3:6 concrete 4 ins. thick. Most of the conduit were laid in unpaved streets or highways. They were laid as near the surface as was possible with the securing of sufficient cover, suitable grade and the avoidance of pipes or other obstructions. The labor cost given includes engineering, inspection, superintendence and everything chargeable to the work except unloading the conduit and the cost of mason and helper on manholes. The cost of draining manholes is included as well as all expense due to removing or changing pipes or other obstructions and removing and replacing such pavements, sidewalks and driveways as were encountered.



DETAILS OF TRANSMISSION TOWERS BUILT BY MILLIKEN BROS. (INC.)

*Civil Engr., U. S. N., U. S. Naval Station, Key West, Fla.

FAIRLIE LOCOMOTIVES are still being built for use on the Burmah railways, according to the "Indian and Eastern Engineer," which illustrates one of these locomotives in the January issue. These locomotives are used on the Mandalay and Kunlong section where maximum grades of 4% with curves of 300 ft. radius are met.

As our older readers will recall, the Fairlie locomotive is really two separate locomotives placed back to back with their cabs adjoining. A continuous frame is common to both machines and each set of driving wheel truck swivels about this frame. All the weight is available for traction and it is distributed over a long space thus reducing concentration of load on track and bridges. At the same time the short wheel base of each truck permits sharp curvature to be used.

The railway in question is of meter gage and the new locomotives have a total weight of 60 tons. The total wheel base is 36 ft. 7 ins., but the wheel base of each truck is only 7 ft. 7 ins.

COST OF LAYING CLAY CONDUIT, LEAGUE ISLAND, PA.

Location.	No. ducts.	Length.	Labor cost per duct ft. cents.	Material per lin. ft. Broken stone, tons.	Material per lin. ft. Cement, bags.	Arrangement of ducts. Horizontal.	Arrangement of ducts. Vertical.
Reserve Basin	4	125′	5.0	0.06	0.25	2	
Reserve Basin	8	341′	4.9	0.08	0.32	4	
Second Street, E.	8	1,260′	6.3	0.08	0.30	4	
First Street, E.	8	795′	5.2	0.08	0.32	4	
Delaware Avenue	8	335′	5.79	0.08	0.30	4	
Delaware Avenue	12	663′	4.9	0.11	0.42	6	
First Street	12	347′	5.75	0.11	0.42	6	
First Street	12	229′	5.3	0.11	0.42	6	
First Street	16	131′	5.24	0.14	0.53	8	
First Street	16	303′	4.07	0.14	0.53	8	
Broad Street	16	780′	3.97	0.11	0.44	4	
Philip Avenue	16	570′	4.5	....	....	4	
Pier 3	20	325′	4.41	0.15	0.60	5	
Philip Avenue	20	520′	4.9	0.16	0.64	5	
Porter Avenue	24	347′	2.6	0.13	0.50	6	
Third Street, W.	32	320′	4.39	0.17	0.67	16	
Philip Avenue	32	100′	4.19	....	....	8	
Philip Avenue	32	229′	3.76	0.15	0.60	8	
Philip Avenue	40	118′	3.02	0.16	0.70	10	
Philip Avenue	48	302′	3.88	0.25	0.95	12	
Philip Avenue	56	264′	3.81	0.25	0.84	10	
Philip Avenue	92	389′	2.14	0.38	1.47	16	

Total duct feet, 181,528.
Labor cost per duct foot, 4.0 cents.
Tons broken stone, 169,208 duct feet, 1063.
Bags cement, 169,208 duct feet, 4183.

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Entered at the New York Post-Office as Second-Class Matter.

The proposition for a new census of water power in the United States, now being considered at Washington, will appeal strongly to our readers. Probably no census report has been of greater value to engineers than the one on Water Power, which formed Vols. XVI. and XVII. of the Tenth Census (1880).

A revision and extension of the water power data so ably marshalled twenty-five years ago by Professors Geo. F. Swain, James L. Greenleaf and Dwight Porter, under the direction of Prof. W. P. Trowbridge, would be of inestimable value to the country. A new census of water power is particularly needed just now, in connection with the comprehensive studies of the water resources of the country so ably begun by the Inland Waterways Commission, whose report we abstract elsewhere in this issue. That report points out the intimate connections between flood prevention, navigation, irrigation, and city water supplies, on the one hand and water power on the other. The possible revenues from the water power created by storage reservoirs built for flood prevention, the improvement of navigation and of irrigation and domestic water supplies would oftentimes be sufficient to ensure a brilliant success for an otherwise financially questionable project. In addition, of course thousands of possible water power developments are quite capable of standing on their own merits, but at the same time most of them would themselves be made more profitable if they were carried out in conjunction with broader schemes for the greatest possible utilization of the flow of a given stream.

Since the Water Power report was published there has been a great addition to the topographic, rainfall and stream-flow data of the country. Some of this very useful information has been brought together by the U. S. Geological Survey, both in its monographs devoted to river systems and in its annual summaries of stream flow data. In the twenty-five years that have elapsed since Professor Swain and his associates concluded their labors, in 1882, vast changes have taken place in the utilization of both water power and of steam power, but of greatest significance has been the advent of electric power. In his Introduction to the Water Power report Professor Swain wrote:

> In comparing water-power with steam-power, the most striking point of difference, and one which at the same time constitutes a great advantage in favor of the latter, is the fact that steam-power is mobile and may be used wherever fuel can be obtained, independently of any particular location. . . . generally water-power is much cheaper than steam-power, but the former cannot be moved, the factory must be brought to the power, and unless the means of approach are easy it will nevertheless be located elsewhere and run by steam.

This lack of mobility of water power as compared with steam power has been more than made good by turning water power into electric power and transmitting the latter to almost any desired distance. Such long-distance electric transmission has but begun, and in it lies much of the future possibility of a fuller utilization of the water resources of the country than has as yet been more than dreamed of.

Much more might be written on so suggestive a subject, and particularly on the comparative smallness of the power enterprises described in the Tenth Census report, but we have perhaps said enough to call attention to the desirability of letting the Bureau of the Census, the Geological Survey and *particularly* members of Congress understand that engineers would highly appreciate a new and thorough-going census of the water power of the United States.

The fire and panic horror at Boyertown, Pa., on Jan. 13 last, in which 169 persons lost their lives, was still fresh in public memory when the news came last week of a holocaust in a school building at Collinwood, Ohio, costing the lives of 167 persons at last accounts. The building was a comparatively new structure, built in 1901. It had brick walls, but the interior was of ordinary wooden construction. The fire started in the basement under the stairway which was the main exit from the building. The fire drill of the children was organized as soon as the fire was discovered, but the children marching down the stairs to the front door found their way barred by the flames coming up the stairway. A second exit doorway at the rear of the building is said to have been closed and locked and in addition it is stated that the doors opened inward.

From the latest information it appears probable that these doors opened outward. A statute in Ohio opposes a fine of $500 on any official who permits the use of a public building with exit doors which do not open outward.

The probable explanation of the crush at the rear exit is that one of the double doorways only was open. The other door was probably bolted at top and bottom in the common way. The contracted exit through the single doorway became choked since the children could not pass through it as rapidly as they came down the stairs. A better illustration of the inherent danger in any contraction in the exits from a public building could hardly be given.

We believe the Collinwood disaster will have a great influence in furthering the adoption of fireproof construction for school buildings throughout the United States. We may go further and say that in schoolhouse construction the time is ripe for a radical elimination of wood trim and finish in addition to the incombustible structure.

Wooden floors may be dispensed with in all halls and passageways, as well as all stairways; and economy, durability and good sanitation, as well as fire protection, will be thereby promoted.

With radical reforms like these, the risk of fire in school buildings could be almost absolutely eliminated, since the combustible furnishings of the building are very small.

Does not the Collinwood disaster furnish a new illustration of the fact that we must look to state supervision, in some form or other, for really effective action in the introduction of reforms affecting public safety? Local building ordinances and building inspection can do much in larger cities; but in smaller cities it cannot be expected that expert knowledge on matters of this sort will be available. Take a concrete illustration and suppose a school building is to be erected in such a town as Collinwood. It is not to be expected that the School Board or the local building inspector, if there were such an official, would have anything more than an amateur knowledge of the art of designing public buildings for safe exit in case of fire or panic. We cannot rely on the architect of the building to look after matters of this sort, for architects as a class are almost as ignorant in matters affecting the safety as the lay public. There are thousands of public buildings throughout the country planned by architects of high reputation and built in recent years which are a standing menace to the safety of their occupants.

The fact we wish to emphasize is that such calamities as that at Collinwood or the great mine explosions in December or the typhoid epidemics at Butler and Ithaca and Scranton—or many other public disasters in which innocent individuals are involved, occur through ignorance, although there is expert knowledge available to prevent or at least minimize such disasters if only it were made use of.

A state can make such expert knowledge available to all the communities in its borders; and where the necessity is great enough it can make the use of such expert knowledge compulsory. Massachusetts is notable among American commonwealths for its work in this direction, and other states are following its lead. We hear talk of the dangers of bureaucracy and of the hampering of private initiative by such state supervision; but it needs only a study of the records of disaster consequent on the old plan of letting ignorance alone to have its unhindered way, for one to appreciate that state supervision is a necessary evolution in our social system.

The heating of electric cars is a problem in which some very serious mistakes have been made in the past. When electricity was first introduced on street railways, electric heaters had a great vogue and still continue in extensive use. In climates where no severe winter temperatures occur, and where the cost of current is not too great, it may be possible to afford the expense of electric car heaters. The trouble is, however, that these heaters have been installed without understanding of the fact that they place a heavy load on the power-house, and that it is a peak load; and not a peak load for 24 hours merely; but a peak load for the year. In order to find the real cost of electric car heating, one should compute the current necessary for heating on the coldest winter's day and then find the cost of the power-station capacity required to furnish that current.

The result of the extensive introduction of electric car heaters has been on the one hand an epidemic of overloaded power stations, and on the other an epidemic of complaints from the traveling public of cold cars.

In New York there is now a Public Service Commission empowered to investigate the complaints of the public and an inquiry was held recently concerning the complaints of cold cars. The inquiry elicited the fact that of the electric heaters installed only one-third were permitted to be used since, if the full equipment were turned on, it would make such a demand for current that the power station would be put out of business.

It is noticeable that in the purchase of new rolling stock at the present day, independent heaters that were supposed to have been permanently abolished when electric heating was introduced are coming back into favor.

An interesting car heating problem has recently been worked out in connection with the through trains entering the Grand Central Station, which are heated by steam from the locomotive. The problem was what to do for heat in these cars when the steam locomotive was cut off and the electric locomotive attached. This change on the New York Central is eventually to be made at South Croton, 34 miles from the terminus, and it would not do in severe winter weather to allow the cars to be without heat all that time. To meet this situation a small vertical tubular boiler has been installed on the electric locomotive and steam from this boiler is

used to heat the cars when the electric locomotive is hauling the train. The boiler is heated by a Kirkwood oil burner and is attended to by the second man on the locomotive.

It is said that experiments have been made on the design of a boiler which would utilize electric heat to raise steam; but it will only be necessary to make careful measurements of the steam used for heating on this run and find the cost of a power station necessary to produce current enough to develop an equal amount of heat when passed through a resistance coil, to show that an electric boiler would be a most expensive luxury.

In the scientific nomenclature of the English language great care has usually been taken to avoid that duplication of meaning which renders many words of our common speech so difficult to the unlearned and to the foreigner. This has resulted so advantageously that it seems some notice should be taken of a very unnecessary ambiguity that has resulted from the coining of the word "telephotography." This word is now being used by the public press to express two distinct ideas, in one case, the art of making magnified photographs by use of a telescopic lens and, in the other, the art of transmitting photographic images by electrical current carried on wires. Both apply to the transmission of the image of a far-distant object, on the one hand by means of light, on the other by means of electricity. To add still further to the confusion the Century Dictionary combines these two ideas in the following definition of a fantastic, though hardly impossible, operation:

> Telephotography.—The art (not yet attained) of producing a photograph of an object distant and invisible from the camera, by means of electrical connections with a suitable apparatus situated near the object.

Historically speaking, the art of telegraphing images probably has the prior right to the term, but having in mind the derivation of the word and the formation of similar compounds and, most of all, the necessity for distinguishing the two phenomena, it would seem wise to reserve "telephotography" for photography with a telescopic lens and to use "phototelegraphy" for the telegraphing of photographs or images, leaving the art defined by the Century Dictionary to be named when it is attained. But even this differentiation does not make matters entirely clear, for "phototelegraphy" has been used, though indeed but rarely, to define the art of telegraphing sounds along a beam of light, utilizing that property of the element selenium by which its electrical conductivity is affected by rays of light of varying intensity.

Thus we have four more or less distinct phenomena for the expression of which our language is decidedly weak; two of present and commercial importance, one of purely laboratory interest and one of only possible future value. Finally, to aid the philologist who may attempt to solve this pretty problem, the art of sending images by electric current has been variously called "telectroscopy," "telediagraphy" and "electrography." The proper selection of the "one apt word" should certainly be left to some more authoritative tribunal than personal preference.

GARBAGE REDUCTION AND INCINERATION PLANTS IN THE LARGER CITIES OF THE UNITED STATES.

The description of the garbage reduction works at Chicago, elsewhere in this issue, again brings to mind the lead that reduction has over incineration in this country. The exact present relative status of the two methods can not be given, but the accompanying table shows that in 1905 no less than 15 cities of over 100,000 population had reduction plants, as compared with 8 cities in the same class having incineration plants. Of the 154 cities with more than 30,000 population, 27, with a total population of 10,200,000, had reduction works, as compared with 32 cities and 3,039,000 population dependent on incineration. If the population of Chicago be added to the reduction column, the total would be more than 12,000,000, or four times the aggregate for the cities that are burning their garbage.

We do not for a moment claim that these figures prove which method of final disposal is preferable, but they do show that reduction is the leading method in the large cities of the country. Why? Chiefly, we take it, because (1) it has been a more attractive field for the exploits of contractors; and (2) because these contractors have spent money and utilized more engineering skill in perfecting reduction processes than the furnace people have in developing incinerating plants. Abroad, all the money and skill has gone into refuse destructors and accessories for heat utilization.

Unfortunately, with all the reduction plants and destructor installations, both sides of the water, there is as yet but little reliable evidence as to the relative economy of the two methods of garbage disposal. This is largely due to deficiencies in municipal statistics and accounting, but that is not the only cause. With the exception of the plant at Cleveland, Ohio, all the reduction works are privately owned, and their financial operations are strictly guarded; all the more strictly because the reduction companies, while maintaining that the revenues incident to reduction make the process less expensive than incineration, yet wish to secure the largest possible bonuses from the cities.

It would seem as though a city might readily enough compare contract prices for reduction with actual or estimated costs of incineration, but the two would be difficult of comparison, even if reliable municipal statistics were available, for reduction works deal with garbage alone, leaving other classes of municipal refuse for separate treatment, whereas incineration works burn a more or less mixed class of refuse. In the United States, it is true, the common practice has been to burn, or attempt to burn, garbage almost by itself, but usually considerable quantities of more or less combustible refuse are mixed with such garbage as is taken to furnaces. Abroad, refuse destructors generally take all classes of refuse, and when any class is partly excluded it is generally garbage—which is then used on land as a fertilizer.

It may be added that many cost figures for operating foreign refuse destructors are published in local municipal reports, but comparatively few such figures find their way to this country. If we saw more of such figures comparisons would still be difficult, owing to a variety of different local conditions in the two countries.

Moreover, and this is a drawback far more applicable to American than European cost data, capital charges, including depreciation, are usually inadequately reported, and inter-departmental charges are either overlooked or else manipulated to favor one department or another. The latter is particularly true abroad as regards the cost data of the utilization of heat in electricity and other municipal works—a matter on which Americans are in particular need of enlightenment, now that refuse destructors, combined with electric works, are beginning to be introduced in Canada and the United States.

Another great difficulty in comparing the cost of reduction and incineration lies in the necessity thereby entailed of separating the cost of collecting from that of disposing of municipal refuse. Where, as at Chicago, the city collects garbage and turns it over to a contractor for disposal, the costs are separated by natural means, but when both collection and disposal are effected by either a contractor or the city the case is far different. Then, too, as Mr. Rudolph Hering pointed out in his recent report on refuse collection and disposal at Milwaukee (see Eng. News, Jan. 16, 1908), the cost of refuse collection, and more particularly of transportation after collection, is liable to vary materially with the method of final disposal in use. With reason or without reason, the generally accepted practice is to locate garbage reduction works far outside a city, or at least at some remote point within the city limits. Incinerating plants, as a rule, are considerably nearer by. The warmest friends of incineration claim that municipal refuse may be burned almost anywhere in a city, and that it is perfectly feasible to have several incineration plants, centrally located, thus saving much on haulage costs, as compared with the heavy transportation charges to remote reduction works. Unquestionably this is a claim that must be reckoned with, even though plenty of opposition to centrally located garbage furnaces is sure to make itself felt in almost any community.

In view of the fact that 69 of the 154 largest cities of the country reported either reduction or incineration plants in use in 1905, it seems high time that reliable comparative data as to the cost of each method of disposal were made available. Just how this is to be done, under existing conditions, is far easier to say than to put into effect. The Bureau of the Census had difficulty enough to secure the most elementary statistics of the physical equipment of the street cleaning, refuse disposal and sewerage systems of the country. Comparative statements of work done have required still more effort and have been yet more unsatisfactory, while comparative costs seem to be hopelessly out of the question until there is a wholesale reform in municipal statistics. Could the administration of street cleaning and refuse removal departments be once taken out of the hands of incompetent men and permanently entrusted to competent engineers, superintendents and foremen, we might soon be able to learn which method of refuse collection and disposal is the least expensive and the most efficient, and whether the necessarily high cost of adequate service can best be reduced by try-

NAMES AND POPULATIONS OF CITIES OF MORE THAN 30,000 POPULATION REPORTING GARBAGE REDUCTION AND INCINERATION PLANTS IN 1905.

(From "Statistics of Cities Having a Population of Over 30,000: 1905." Special Report, Bureau of the Census.)

Reduction. City.	Population, 1905.	Incineration. City.	Population, 1905.
New York, N. Y.	4,000,000*	San Francisco, Cal.	380,000†
Philadelphia, Pa.	1,417,000	Milwaukee, Wis.	313,000
Boston, Mass.	595,000	Minneapolis, Minn.	262,000
Baltimore, Md.	546,000	Los Angeles, Cal.	200,000‡
Cleveland, Ohio	437,000	Memphis, Tenn.	121,000
Buffalo, N. Y.	377,000	Scranton, Pa.	116,000
Pittsburg, Pa.	364,000	Portland, Ore.	104,000
Cincinnati, Ohio	343,000	Atlanta, Ga.	103,000
Detroit, Mich.	328,000	Grand Rapids, Mich.	98,000
Washington, D. C.	303,000	Lowell, Mass.	95,000
Indianapolis, Ind.	212,000	Richmond, Va.	87,000
Toledo, Ohio	156,000	Trenton, N. J.	84,000
Allegheny, Pa.	143,000	Wilmington, Del.	84,000
Columbus, Ohio	142,000	Camden, N. J.	83,000
Paterson, N. J.	112,000	Troy, N. Y.	76,000
Dayton, Ohio	98,000	Oakland, Cal.	73,000
Reading, Pa.	89,000	Evansville, Ind.	63,000
Bridgeport, Conn.	82,000	Yonkers, N. Y.	61,000
New Bedford, Mass.	74,000	Salt Lake City, Utah	59,000
Duluth, Minn.	65,000	Norfolk, Va.	58,000
Utica, N. Y.	64,000	Houston, Tex.	56,000
Waterbury, Conn.	60,000	Terre Haute, Ind.	52,000
Johnstown, Pa.	42,000	Youngstown, Ohio	52,000
McKeesport, Pa.	42,000	Fort Wayne, Ind.	50,000
York, Pa.	38,000	Lancaster, Pa.	46,000
Atlantic City, N. J.	38,000	Covington, Ky.	46,000
New Castle, Pa.	35,000	South Bend, Ind.	43,000
		Butte, Mont.	42,000
		Wheeling, W. Va.	41,000
		Allentown, Pa.	41,000
		Canton, Ohio	38,000
		Joliet, Ill.	32,000
Total (27 cities)	10,200,000	Total (32 cities)	3,039,000

*There were a number of small garbage furnaces in outlying districts of New York in 1905.
†San Francisco population for 1904.
‡Los Angeles population not given in original; estimated in round numbers here.

ing to recover grease and fertilizing material from garbage or by utilizing the heat from mixed refuse. As it is, the most that can be said is that of the 154 largest cities of the country, 27, including the largest, employ reduction, and 32 depend on incineration, without being able to determine conclusively whether this is the result of accident or wise choice; or if we conclude, as there is reason for doing, that it is largely due to accident, we certainly cannot say whether it is the part of wisdom to continue or to change the methods in vogue.

The hopelessness of the situation is forcibly illustrated by the report on street cleaning and waste disposal in New York City recently made by Messrs. H. de B. Parsons, Rudolph Hering and Samuel Whinery, in which the temporary continuation of garbage reduction for the greater part of New York City was advised, largely because of the lack of data on which to base an opinion as to the advisability of a change to incineration—a method preferred by some, if not all, of the experts. Some day the municipalities of the country will recognize the fact that the collection and disposal of street dirt, garbage, ashes and rubbish is an intricate question, the solution of which must as necessarily be entrusted to engineers as must the design, construction and operation of water-works, sewerage, lighting or transportation systems.

LETTERS TO THE EDITOR.

A Peculiar Accident with Explosives.

Sir: A fatal accident occurred in Boston the past week, and through your columns I seek for information which may guide to the solution of a mystery.

The water department was blasting a trench where so far as known no previous operations of the kind had ever been undertaken; although blasting had been done in the same street 5 ft. away. A laborer was engaged in picking out rock just shattered by a blast, when his pick struck some dynamite, which promptly exploded. This was at a point 4 ft. below the original top of the rock.

Eliminating the possibility of there being an old charge at this point, could the following solution be reasonable? I found that the contractor had—after drilling—inserted in a 4-ft. hole just above where the accident occurred, three half-sticks of forcite, one above the other, the exploder or cartridge being placed in the central half-stick.

Could the lower half fail to explode, to be picked soon after by the laborer? All the forcite was thawed every morning before use. The temperature for several hours preceding the accident was about 40°.

Yours truly,

Frederic I. Winslow, Asst. Engr.

50 City Hall, Boston, March 7, 1908.

[That our correspondent has given the correct explanation may be seen by a process of exclusive reasoning. The explosive was not placed in the rock by Nature and could not have been placed there prior to the present work or the rock would not have been there solidly in place. As dynamite freezes at about 45° the probability is that some of the explosive became cold enough to freeze after being thawed in the morning. Part of the charge being thus frozen did not explode with the rest but was thawed later, perhaps by the heat resulting from the blast, and was in condition to explode when struck by the pick.—Ed.]

Maximum Shear in Columns, and the Point of Maximum Shear.

Sir: The ratio of maximum to average stress increment, that is the ratio of maximum to average shear, in a beam or column depends on the form of the moment diagram. If this diagram is a parabola the ratio is 2, if it is sinusoid the ratio is $\frac{1}{2}\pi$ (1.57 about). In a criticism of Prof. Morris' article on "The Lacing of Compression Members," the writer claimed that the ratio in question, for a column loaded eccentrically varies according to conditions between the limits $\frac{1}{2}\pi$ and 2; and advised that the higher limit should be assumed in practice.

Prof. Morris in his reply, in your issue of Feb. 27, 1908, claims that under the conditions of practice this ratio will be less than $\frac{1}{2}\pi$, and supports his contention with an analysis the accuracy of which depends, among other things, on a statement which he makes without demonstration, that the shear increment is a maximum when "x" (the distance from point of maximum bending moment to point under consideration) equals zero; that is, he claims that the shear is a maximum at the point of maximum bending moment. On the other hand Engineering News, in editorial comment on Mr. Morris's letter, states that the shear is greatest at the ends of a pin-ended column, or at a point of inflection in a continuous column.

The position of the point of maximum shear is the crux of the contention herein cited. The writer holds with Engineering News that it is at an end or a point of inflection and not at the point of maximum moment. If the reader has any doubt on the subject he can refer to any authoritative work on Mechanics. Merriman's "Mechanics of Materials," seventh edition, which happens to be at hand at this writing, states and demonstrates on page 55 that "the maximum moment occurs at the section where the vertical shear passes through zero."

Yours respectfully,

Henry S. Prichard.

Room 1526 Frick Building, Pittsburg, Pa., Feb. 29, 1908.

[To this letter Prof. Morris makes reply as follows.—Ed.]

Sir: At no place has the writer made the statement that the shear was maximum when $x = 0$, but, on the contrary, Eq. (7) of my letter in your issue of Feb. 27 gives S as a maximum from Eq. (4) when $x = l$.

The "v" of my Eq. (5) is not the shear, but the rate of change of the shear, which is maximum when $x = 0$ and when the shear is passing through zero.

It is evident by considering Eq. (7), for the shear, that θl can never attain a value $\frac{\pi}{2}$, for in that case $\tan \theta l = \infty$ and the shear would be infinite.

Yours very truly,

C. T. Morris.

Columbus, Ohio, March 5, 1908.

Laying Out Curved Boundaries for City Lots.

Sir: Having had considerable work in laying out lots with curved boundary lines, of which only the radius and lot corners were given, the writer used the following method which may be of interest to your readers.

Assume a chord length, $c = 1/100\ R$, then the deflection angle, $\delta = 17'\ 07''$. On this angle (which of course remains constant for all radii) is based the whole system. To illustrate: Set the instrument at one point on the curve, and with vernier set at 0°, take a sight at the other point on curve. Deflect the angle and measure the chord distance, c, from the foresight towards the instrument. Add δ to the angle already deflected, and so on as in railroad curves. When the instrument is reached, the curve can be produced by reversing the telescope and continuing as though the instrument point did not exist. If it is desirable to know the central angle, Δ, measure the sub-chord length between the transit and the last "station" before reaching the transit. Call this sub-chord, c'; then $c : c' :: 17'\ 07'' : \theta$. Let n = number of chord lengths of length c, then $2\ (n\,\delta + \theta) = \Delta$.

Obviously, if the chord lengths are very small, the labor of putting in all the points would be enormous, consequently we omit sufficient of the points to give us approximately the chord length best suited for our purpose; In other words, we use a chord length, C, with values other than $R/100$, as for instance, $C = R/10c$. For staking out curbs, sidewalks, etc., the writer finds that $C = R/25$ gives the best results, while for grading, $C = R/10$ is sufficiently accurate.

The appended table gives the value of δ for various values of C, the numbers in the last columns referring to the "station" enumeration.

DEFLECTION ANGLES FOR CURVES
when R = 100c, etc.

Deflection.	100c.	50c.	33⅓c.	25c.	20c.
0° 17′ 07½″	1	..	..	..	..
0° 34′ 15½″	2	1	..	..	..
0° 51′ 23¾″	3	..	1	..	..
1° 08′ 31″	4	2	..	1	..
1° 25′ 38¾″	5	..	..	..	1
1° 42′ 46½″	6	3	2	..	..
1° 59′ 54¼″	7	..	..	..	..
2° 17′ 02″	8	4	..	2	..
2° 34′ 09¾″	9	..	3	..	..
2° 51′ 17½″	10	5	..	..	2
3° 08′ 25¼″	11	..	..	..	..
3° 25′ 33″	12	6	4	3	..
3° 42′ 40¾″	13	..	..	..	..
3° 59′ 48½″	14	7	..	..	..
4° 17′ 56¼″	15	..	5	..	3
4° 35′ 04″	16	8	..	4	..
4° 51′ 11¾″	17	..	..	..	..
5° 08′ 19½″	18	9	6	..	..
5° 25′ 27¼″	19	..	..	..	..
5° 42′ 35″	20	10	..	5	4
5° 59′ 42¾″	21	..	7	..	..
6° 16′ 50½″	22	11	..	..	..
6° 33′ 58¼″	23	..	..	..	..
6° 51′ 06″	24	12	8	6	..
7° 08′ 13¾″	25	..	..	..	5
7° 25′ 21½″	26	13	..	..	..
7° 42′ 29¼″	27	..	9	..	..
7° 59′ 37″	28	14	..	7	..
8° 16′ 44¾″	29	..	..	..	..
8° 33′ 52½″	30	15	10	..	6

Set transit at A, sight on B, measure chords and deflect from B towards A.

Yours truly, H. H. T.

Baltimore, Md., Feb. 17, 1908.

A Society Journal of Mechanical Engineering.

Sir: A news item stating that Mr. Lester G. French, formerly Editor of "Machinery," has been appointed Editor of the Monthly "Proceedings of the American Society of Mechanical Engineers" and of its "Transactions," also suggests a plan by which the work of the Society could be made more effective and more valuable to manufacturers and engineers, especially if it should be possible to combine the efforts of several of the societies, but more especially the Mechanical, Electrical and Heating and Ventilating Engineers on a single weekly or monthly engineering publication. This could be made more interesting and more readable than the separate proceedings published by the several societies, qualities which the individual proceedings lack in some measure because of their formal and perfunctory character.

Such a journal would be similar to the "Zeitschrift des Vereins Deutscher Ingenieure" and would provide what we lack in this country, viz., an able journal of mechanical engineering. Hardly any one will assert that there is a professional mechanical engineers' journal published in the United States that compares in sustained high quality and quantity of output with London "Engineering," for example.

We need a journal of this kind, both as manufacturers and as professional engineers, and it is to be hoped that the appointment of Mr. French will lead to the fulfillment of the want. We now have no paper by which a purely technical discussion on, let us say, the mathematical theory of air currents, would be welcomed, or at least none by which it would be sought out, except possibly for the proceedings of the Am. Soc. M. E., and the matter might not be in the final and permanent form required for that august record.

There is no publication that constantly stimulates and records the steps in the progress of mechanical engineering, with the possible exception of those devoted exclusively to steam engineering.

Further than this, the Engineering Societies are now in a position to do something towards making more available the vast store of technical information filed in their libraries. In this connection the following paragraphs, which I published in a small pamphlet in April, 1906, may be of interest:

The United Engineering Building, when completed in New York City, will greatly facilitate the cooperation of the national engineering societies in the promotion of engineering science. The bringing together of the several libraries of itself will be a great benefit. As matters now stand, much labor and time are required to get a complete review of the state of the art in any extensive branch of engineering or manufacturing. In fact, it is practically impossible, and costly experiments and investigations are frequently duplicated by different manufacturers to arrive at identical results; often to arrive at results which, somewhere or other, have been placed on record. This would not happen if such information were suitably arranged and classified.

A commission representing the leading engineering societies should be appointed to undertake the codification, or at least the indexing, of engineering information. This commission, in turn, could employ editors and investigators, who, in the collected libraries of the united engineering societies, would have the finest facilities. Work could be begun by collecting and comparing information relating to the properties of materials, since such information would evidently have the widest and most immediate use. Processes and methods could then be taken up, and not only should descriptive information be collected, but also data relating to efficiencies and costs.

Such information, when collected, classified and arranged, should be made available in convenient files accessible to all members of the societies. If suitably condensed and published in the form of books there is no doubt that their sale would many times repay the cost of compilation.

Yours very truly,

The Geo. H. Gibson Co.,
Per Geo. H. Gibson.

February 29, 1908.

[Without desiring to criticize any particular English publication, we venture the opinion that American technical literature, both in journals published by private enterprise and in the published proceedings of technical societies, is far in advance of either England or Germany. The standard to be applied in judging technical literature, we maintain, is its practical usefulness to the working engineer. Analyze foreign journals by this standard and see how small a proportion of their space is taken up with actual problems of design and construction. Make a critical comparison of the published proceedings of the British Institutions of Civil and Mechanical engineers and the corresponding American societies, and it will be found that the latter have vastly more matter that is of direct usefulness.

As to there being no place in this country where a really valuable paper on mechanical engineering subjects can find publication, we need hardly say that Engineering News is always in the market for such contributions and so are other American journals.

As to the proposals made in the last two paragraphs quoted above, we see many serious

practical difficulties in carrying them out. If the work were to be well done by a competent staff, its cost would be enormous; and if the work were not well done, it would be worse than worthless.

Besides, no one is wise enough to judge what information is worth compiling. Work of this sort is best left to private enterprise. The concern that wants information knows how much it can afford to pay to secure it. The collection, classification and publication of existing data is a work now being successfully carried on by the private enterprise of authors and publishers, and their own self-interest is a safeguard against spending time and money in the collection of information of no value to the profession.—Ed.]

Concerning "The Function of the Consulting Bridge Engineer" and Bridge Constructing Companies.

Sir: In a recent number of your paper Mr. J. A. L. Waddell has taken issue with your editorial comment in regard to the preparation of plans of bridge work by contractors or by consulting engineers. Mr. Waddell's contributions to the engineering work of this country have been so notable, and for the most part so excellent, that the writer naturally feels some hesitation in taking issue with him on this most important question; at the same time the writer is aware that his ideas on this matter are shared by some of our best engineers, and he feels moreover that the other side of the question should be briefly presented. Mr. Waddell's sweeping statements seem almost in the nature of a challenge.

The writer believes all will agree that the present state of the art of bridge design is far from satisfactory. One finds plenty of bad designing on every side, sometimes covered up by an extravagant use of metal and sometimes not. But the bridge companies are by no means the only or the worst offenders. The writer in his capacity of contracting engineer for a bridge company, both in the east and west, has for years had ample opportunity of examining engineering work in all stages of construction and plans submitted by a great many engineers of high or low degree, and knows whereof he speaks.

We are all vitally interested in the improvement of bridge design and none more so than the bridge companies themselves. We are in business to stay and the day is past when a nominally reputable company would build something they knew was wrong for the sake of a few dollars additional profit. Bridge companies of the better class are officered by able and conscientious men and they are building bridges as well as they know how, and always looking for something better. Their *knowledge* is not always perfect, but they share this deficiency with the consulting engineer as well as with humanity in general. It may be asserted without fear of successful contradiction that the contracting engineer for a bridge company by his constant contact with designs from all sources, by criticism of his own designs, by his constant association with the problem of manufacture, and by his constant opportunity for noticing the behavior of structures in use, runs less chance of falling into a rut and has better opportunities for improvement in knowledge of design than the average consulting engineer.

Nor is the contracting engineer, although so branded, alone tainted with commercialism. This is a question of the individual. We all have our commercial interests, which are sometimes (one might say usually, when viewed from a small or selfish standpoint) opposed to the best interests of our clients or customers. Who shall say that one class of engineers yields more frequently than the other? You will find men in both great divisions of the engineering profession, working for the work's own sake, and neither desiring nor gaining any reward that does not rightly follow their effort.

As for the commercial spirit in its best sense, namely, the common sense and practical adaptation of the means to the end, the careful weighing of cost with regard to results attained and the true economy that considers in a farseeing way the best interests of clients, customer or user: you will find this rare quality more frequently in the bridge companies than elsewhere.

The commercial or contracting engineer is also more apt to approach his work in an appropriately humble spirit. He has the tremendous advantage of being always subject to free and unhampered criticism. He realizes that we are all learners, and that the best practice of to-day may be obsolete to-morrow, while the consulting engineer, who is freed from most of this by so called "professional etiquette," thereby loses a strengthening and vivifying influence that it takes a really great man to do without.

Mr. Waddell's description of the qualities necessary in a consulting engineer sets an almost impossible standard. Even if we could imagine any one so endowed, would not his opportunities and the real value of his work be vastly enhanced if he were able, through his association with the constructive energies through which his ideas are now carried into effect, to actually do the work that he now directs? This is no new doctrine. Did not Stevenson, Smeaton, and other pioneers in the engineering profession, and have not many of the most illustrious of their successors, constructed their own works? Are not the great engineering companies that furnish the world with its locomotives, electrical equipment, signaling apparatus, etc., largely responsible for the progress in those lines and has not a competition of excellence resulted that has done more for engineering than if all designs had been prepared outside and the bidders had only been requested to see who could do the work most cheaply? A man who does his work as well as plans it is more and not less of an engineer.

Now to the main point of these remarks. No one can claim infallibility. We need the earnest cooperation of all parties engaged in engineering work in order to obtain the best results. Our aim should be to improve the designing departments of our bridge companies and not to spend our time imposing more and more impossible demands, and our energies in watching to see that they are carried out. In the writer's judgment the preparation of detail plans properly belongs to the bridge company, and a consulting engineer in most cases is not serving his clients' interests, or helping the progress of the profession, when he does or attempts to do this work himself, or when he closes his ears to suggestions from the contracting company.

The results attained and the progress made by the engineers connected with the bridge companies have been in spite of, and not in consequence of, the conditions of their work. No wonder that the commercial spirit has usually controlled them, when they are seldom asked "How well can you do a thing?" but only "How cheaply can you do it?"

It also seems to the writer that greater success can be attained by the consulting engineer by devoting his principal attention to the larger aspects of his work, and placing full responsibility on the contracting company. Here we avoid that terrible danger of divided responsibility by placing it entirely on the only party able in the nature of things to sustain it.

No one realizes more fully than the writer how difficult it is under present competitive methods for a bridge company to do itself justice. The penny-wise and pound-foolish competition of to-day must some time grow into a "competition of excellence" where excellence of design and construction and true and farsighted economy will be the objects sought, and mere competition of price will be classed, as a form of industrial war, with other kinds of war that are already under the ban of civilization.

The writer also realizes that there is a great deal more to be said on this most important question, and that opinions will greatly differ on matters of everyday policy even if they agree on the ultimate conditions to be striven for. The writer trusts, however, that these remarks will not prove out of place; at least they express the writer's sincere conviction, developed during many years of active connection with engineering work.

Andrews Allen, M. Am. Soc. C. E.,
Contracting Engineer,
Wisconsin Bridge & Iron Co.

Chicago, Feb. 28, 1908.

"Why the Corps of Engineers Should Continue in Control of River and Harbor Work."

Sir: I read with a great deal of interest the article of Major Gillette, entitled "Why the Corps of Engineers Should Continue in Charge of River and Harbor Work" in Engineering News of Feb. 6, as it is a subject that has attracted my attention for several years. For some time I have felt that the work should be placed in the hands of a purely civil corps.

Major Gillette apparently suggests that the work would be endangered by dishonest engineers if placed in the hands of civilians and suggests that the graft politicians are creeping in. Whether he has reference to the scandal in the Corps of Engineers at Savannah, which is one of the very worst examples of dishonest engineering our country has ever seen, or some other case, I do not know; but I feel certain that the dishonest element in politics is on the wane instead of on the increase.

For example, take the Pennsylvania Capitol frauds for which the perpetrators are just keeping out of prison while a few years ago corruption was so common that no one paid any attention to it. Very recently the officers of several large corporations saw prison staring them in the face for unlawful contributions to campaign funds in the last presidential election; but 25 years ago men walked about at the polls with ballots in one hand and rolls of bank notes in the other and bought votes at wholesale.

Major Gillette says the engineer officers have their stations changed frequently. Right there is one of the weakest points in the administration of the corps. What business organization would constantly change the chiefs from place to place before they had a chance to know the work?

The Major speaks of "The most menacing defect in our system of government" and refers to the graft and loot to be had from the fact that votes count; but he will find that in absolute monarchies, such as Russia and Spain, the graft and rotten contracts are far beyond the wildest dreams of our spoilsmen. Many people seem to have the same mistaken idea about "our system of government" being so much worse than the others, while they do not know or have forgotten about the others.

Very truly yours,
Willard D. Lockwood.

Schenectady, N. Y., Feb. 13, 1908.

Sir: The writer would like to contribute a few opinions to the discussion now going on in these pages as to whether the river and harbor improvements of this country should be administered by a bureau of civil engineers or whether the corps of engineers of the U. S. Army should continue in charge. Some years ago the writer was connected with river and harbor improvements, and he feels that he is conversant with this subject.

The corps of engineers has done admirable work and is an honest and efficient body of men, but to take the stand that one of your correspondents has recently taken, that no other body of men can be depended upon to administer river and harbor works honestly is to make a statement which cannot go unchallenged. A bureau of civil engineers founded on a true merit system would furnish educated engineers experienced in this class of work who would without doubt do as good work as has been accomplished by the military engineers.

Both West Point and the engineering schools draw their students from the same social classes of our population. The early moral training of the technical student and the cadet is the same. The instructors at the technical schools are often engineers of eminence while the instructors at the military academy are officers not as a rule under temporary detail as instructors. To turn out engineers is the sole aim of the technical school; to turn out soldiers is the object of the military school. A young man enters West Point to become a soldier, while a student at technical school intends to adopt engineering as a profession. At the technical school engineering is the main study of the course, while at a military school engineering is only an incidental study. Thus far of the two young men, the civilian on account of his education is the better fitted for the execution of engineering works, and if after qualifying for admission into a high grade corps of government civil engineers, this young man is given the opportunities for study, observation and professional experience that are now accorded the members of the Corps of Engineers of the Army, he will make as efficient a public servant as members of the military corps. The members of such a civil body would take the same pride in their efficiency, and would be just as jealous of their honesty as any military body.

As to the civil assistants now employed under the officers of the army engineer corps, they are a body of men who almost deserve pity. They are in a large measure responsible for the good record of the Engineer Corps, but receive little recognition and compensation. Scarcely a payment is made at a U. S. Engineer Office without the signature of one of these assistants, and yet your correspondent implies that honest administration could not be had with a civil body. The civil assistants not only receive poor pay, but have no opportunity of receiving advancement by promotion to engineer-in-charge of an office. By law, they are shut off from advancement. Gray-haired eminent engineers often serve under boyish lieutenants. This condition tends to drive efficient civil assistants from the government service on rivers and harbors.

There is much room for improvement in the organization of this branch of the government service, especially since the river and harbor improvements are assuming large proportions, and the writer thinks that a journal of the standing and influence of Engineering News can do much towards bringing about a needed change, or at least some very desirable improvements.

Yours truly,
A. R. B.

St. Louis, Mo., Feb. 10, 1908.

[Our correspondent speaks truly of the inadequate pay and positions of the U. S. Assistant Engineers; but this could be bettered by very simple legislation. The real question is: how could a civilian body of executive managers be secured who would be as trustworthy, and as free from political influence and corrupt manipulation, as are the present officers of the Corps of Engineers? Our correspondent refers to "the merit system"; but we must recognize the limitations of this system. Excellent as it is for the selection of men in the lower ranks, it is absurd to select men for executive positions of large power and responsibility by a civil service examination. It is often attempted by "the merit system" to put barriers in the way of the removal of men for political or other improper reasons; but these same barriers often stand in the way of the removal of men who prove incompetent.

No one doubts the ability and honesty of civil engineers as a class; but the question is how

could we place and keep that class of men in the service and prevent the politicians and the grafters from displacing them with men who would be subservient and would permit all sorts of crooked work. The U. S. Assistant Engineers have made an enviable record because they have had the backing of the engineer officers; but if they could be displaced by the exertion of political influence when their decisions happened to injure someone with large financial interests at stake, the good men might be forced out of the service.

We submitted proof of the above letters to Major Gillette and append his reply as follows.—Ed.]

Sir: I note the comments of A. R. B. and of Mr. Lockwood upon my letter concerning the Army Corps of Engineers and River and Harbor work. I am rather surprised that both appear to read into my letter a statement to the effect that "no other body of men can be depended upon to administer river and harbor works honestly." I did not intend to make that assertion, and I cannot see why your correspondents should have taken it as an inference.

However, now that the point has been raised, it is worth discussing. In the training of youth, the West Point system is decidedly more vigorous in the detection of tendencies to dishonesty than are the systems of other schools. A bright man who is inherently dishonest can go through an ordinary college training, and his tendencies not develop until he gets into business, later in life. Characteristics of that kind only show up in proportion to the pressure. The West Point system puts on this pressure intensely and continuously. A soldier's honor and a soldier's honesty are vital to the military service and, as such, are necessarily a more important part of the school training at West Point than at other schools. This is not intended primarily to make engineers but to make soldiers who can be depended upon under stress, but the army branch of the engineering profession gets the benefit of it.

Its value is borne out by the record. There is no body of men in the world's history with so clear a record for financial probity as the Corps of Engineers. That the one brilliant crook, Oberlin M. Carter, referred to by Mr. Lockwood, slipped through West Point and robbed the Government at Savannah, is practically the single exception to the honorable record of a great body of engineers, extending over a great many years and the disbursement of a great many millions of dollars.

There were some incidents of the Savannah frauds that are worth mentioning in this connection. Many engineer officers did not believe Carter could be guilty, and some of them gave testimony which may have helped him, but the only two engineers who took the entire case upon their shoulders, and, after investigation, testified that Carter was not guilty, were civilians who had previously been assistant engineers in the Government service, upon river and harbor work. They were the only ones who "went the limit" to help protect the thieves.

A. R. B. asserts that "a bureau of civil engineers founded on a true merit system" would be all right in every part, and their work would equal that of the Army engineers. Assuming that such a corps were organized and every man in it were thoroughly honest and of a high grade professionally, there would not be one among them who, if he went against the wishes of powerful politicians or powerful financial interests, could not be removed through their influence and replaced by a more flexible or dishonest man.

That cannot be done with the Corps of Engineers. They can only be displaced as a body. Grafting politicians might possibly remove any individual of the Corps, but they could have no say in replacing him with a man of their choice. The Corps will doubtless always be replenished at the bottom from selections made through the careful and trying processes of West Point, and the interests of the Army, which will always be paramount to the interests of the Corps of Engineers, will always prevent any tampering with the character of the output of that school.

A. R. B. makes the point that the civilian sudents are trained by engineers and the cadets by "officers." It should be noted that the "officers" who teach engineering are also engineers. And he makes no note of the post-graduate course of three years in engineering at the engineer school.

Mr. Lockwood makes a point against officers changing stations. A civilian bureau would be in the same condition as to that. It is one great work; changes in station are seldom imperative but are undoubtedly beneficial.

A "true merit" system is a good thing when it is enforced, but its enforcement depends entirely upon the officials who administer it, and when these, or those who appoint them, are spoilsmen, some erratic results may be expected. For example, the city of Philadelphia has a civil service law drawn up under the auspices of the State Civil Service Reform Association and is as complete and perfect as such a law could be made. Yet, at the present time, the Mayor of the city, who quitted the House of Representatives to accept the place, says that such a law is absurd. He has appoined a commission who practically nullify the law, and practically all employes, including engineers, are appointed and discharged entirely at the will of the political boss, who incidentally gets all of the large city contracts. This contractor-boss can remove at will the director who appoints the inspectors on the contracts, and the mayor stretches the law wherever necesary to juggle contracts into the hands of the boss.

What can happen to a city with a million and a half of people could easily happen to the national river and harbor works. Imagine this enormous appropriation administered as are Philadelphia contracts!

Under a previous administration, the same political boss secured the appointment of a chief engineer, who so manipulated the contracts that on one work the city lost about five millions of dollars. The mayor at that time, who also had been a creature of the political boss, took an affidavit in a civil suit that through a conspiracy between the contractor-boss and the city officials, the city had been robbed of the above five million dollars. But he lacked the courage to arrest them on a criminal charge to the same effect. Under the auspices of the Army Engineers, Green, Gaynor and Carter went to the penitentiary.

Mr. Lockwood thinks that conditions in the United States are improving. I beg to assert, from an intimate knowledge of the facts, that in Philadelphia, at least, they are growing worse. A few years ago the political boss kept his connection with public contracts a profound secret. But this connection was exposed to the public in the course of legal proceedings and now the boss takes them openly; many in his own name.

Mr. Lockwood also thinks that we are to be congratulated because we are not so bad as Russia. Our danger in graft matters is that we are likely to grow toward the Russian condition unless steps are taken to check that form of "dry rot" and turn conditions in the better direction. In doing this, we can safely leave undisturbed our river and harbor work, which under the administration of the Corps of Engineers of the United States Army, is more free from graft than any other work of equal magnitude in history.

But I still maintain that the most important reason for leaving our river and harbor works where they are, is to train our engineer officers for their duties in time of war. It is a tendency of republics to neglect military training, and our Army, to-day, would be quite unprepared for a war of any magnitude, should one break out suddenly. But thanks to the fact that our Army engineers get a practical training on the river and harbor works that is of inestimable value in time of war, the Engineer Department is probably the best prepared of any branch of the military service to meet its duties, should a war come to-day, without warning. The large body thus profitably employed in time of peace is of inestimable value in time of war.

That the Corps of Engineers does its work well and that the people of the United States are satisfied with its methods and results, is shown by the cessation of the Panama Canal turmoil as soon as this work was put with the rest of the river and harbor works, under the charge of the Army Engineers.

Very truly yours,

Cassius E. Gillette.

1031 Land Title Building, Philadelphia, Pa., March 4, 1908.

HIGH RELATIVE RATES OF FILTRATION WITH SLOW SAND FILTERS.

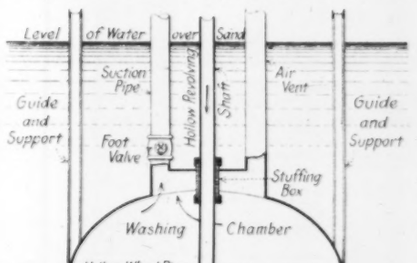
By WILLIAM B. FULLER,* M. Am. Soc. C. E.

Nearly all of the slow sand filter plants, both in this and foreign countries, have been designed and operated at a rate of 2,500,000 to 3,000,000 gals. per acre per day, and so universally has this rate been accepted as a maximum that but few have questioned it. This is all the more singular because of the fact that the results of tests of experimental filters, carefully conducted by well known engineers at the Lawrence Experiment Station of the Massachusetts State Board of Health, also at Louisville, Cincinnati, New Orleans and Springfield, have conclusively demonstrated that much higher rates are feasible. The explanation is that a low rate affords greater convenience in operation than would a high one, owing to the universal method heretofore used for cleaning filters. This method consists, as is well known, of drawing off the water from the sand surface of the filter to be cleaned, scraping off a thin layer of sand from this surface, transporting this sand to sand washers outside the area of the filter, restoring the water level in the filters, and then re-starting at slow rates, which are continued until the filter is again ripened enough to run at nominal rates.

The operations of sand scraping and transportation require a large number of laborers and it is desirable that they be employed during working daylight hours; all of the operations occupy from three to five days' time. During this period the filter is performing no useful work of filtering the water and in addition other filters must be provided to keep up the nominal supply. These two conditions operating together require that there shall be a very long period between cleanings: the first, in order that a delay of twelve hours to obtain daylight working hours will not affect the operation of the plant; the second, so that the percentage of the time the filter is out of service to the operating time will not require the construction of a large number of reserve filters.

As a further result of these two conditions, engineers have had to select a size of sand which will give the greatest yield consistent with the desired bacterial purification, and this size is frequently so large as to allow the passage of fine particles of suspended matter.

The progress of the improvement of the slow sand filter has been, therefore, very seriously retarded by the prevalent method of cleaning. A method of cleaning which would keep the filter



Washing Chamber of Blaisdell Filter-Sand Washing Machine.

(Invented by H. W. Blaisdell, Los Angeles, Cal.)

(The chamber being slowly moved ahead, sliding on its shoes over the sand surface, water is forced through the hollow shaft to the hollow rim of the wheel, and thence to the hollow teeth below and through fine perforations into the sand. The dirty water from the washed sand is drawn away from the washing chamber through the suction pipe.)

out of service only an hour or so and would do this work with only one or two operatives, working any hour of the day or night, would make possible many other improvements; such, for instance, as using sand of an effective size proportioned to the work it has to do in removing turbidity and bacteria and not according to the length of the run between cleanings, and, most important of all, allow higher rates and a consequent reduction in first cost of construction.

That the rate of filtration is greatly affected by the time the filters are out of service in cleaning is well shown by an example, it being well understood that the rate of filtration does not materially affect the quantity of water filtered between cleanings of the sand surface or the time lost in any single cleaning. Assume a rate of filtration of 3,000,000 gals. per acre per day. Then with 60,000,000 gals. of water filtered per acre between cleanings, and three days lost during cleaning, the filter would be out of service 13% of the time and 15% reserve area would be required to maintain the nominal rate. Change the above rate to 10,000,000 gals. per acre per day, the other factors remaining the same, and the filter would be out of service 33% of the time and 50% reserve area would be required to maintain the normal output.

A rapid method of cleaning slow sand filters, such as has just been outlined as necessary for high rates, is furnished by the Blaisdell filter sand washing machine, which has been thoroughly tested under the supervision of the

*Consulting Civil Engineer, 170 Broadway, New York City.

writer, during the past six months, by authority of the city of New York.

Such a machine has already been in operation at Yuma, Ariz., for four or more years, on a slow sand filter, clarifying Colorado River water, having an average turbidity of over 2,000, at a rate of 3,000,000 gals. per acre per day, through sand having an effective size of 0.13 mm., without the use of any coagulants, at a very small maintenance cost and with satisfactory results.

The Blaisdell washing machine consists of an inverted open box about 4 ft. sq. and 2 ft. deep, together with suitable operating mechanism, shown in section herewith. The box is sunk under the water of the filter to the sand surface and held in position and operated from a platform above, which platform is movable on rails supported by the piers of the filter. The box contains a revolving hollow axle and a hollow head from which hollow teeth project into the sand any desired distance.

By means of suitable electrically-driven mechanism, all under the control of one operator, the box can be raised or lowered and the platform can be moved backward or sideways. By moving the platform the box is caused to slide over the surface of the sand at a speed of about 10 ft. per min., while at the same time the hollow head and teeth are made to revolve slowly, stirring the sand mechanically. Water under a pressure of 10 to 20 lbs. per sq. in. is introduced through the hollow axle, head and teeth and passes in strong fine streams into the sand through fine holes in the teeth.

A suction pump connected with the top of the box is made to draw away just a little more water than is supplied through the teeth, and thus carries away and discharges to a sewer all of the dirt which has been stirred and washed from the sand. On account of some water being drawn inward from the filter into the box under its edges through the sand to make up the deficiency between the amount pumped out and that let in through the teeth, none of the dirty water escapes from the box into the filter, but all is carried away and discharged through a flexible hose into the sewer.

The box is slowly moved ahead over the sand, and thus every part of the sand surface is gone over and cleaned, after which the machine is lifted from the filter and filtration started. All the operations of the machine are at all times easily under the control of one operator, by simply throwing electrical switches.

This machine was successful under the New York experiments and has been recommended for adoption when the proposed Croton filters are constructed. By its use rates of 10,000,000 gals. per acre per day are entirely feasible, in the opinion of the writer, even with waters quite highly charged with either bacteria or turbidity or with both. This is aided by intelligent proportioning the effective size of the sand, the depth of sand washed at each cleaning and the rate of travel of the machine during washing.

It is well known that sand filters possess the property of storage of bacteria and turbidity for certain periods; that is, if a filter running under normal conditions of bacteria and turbidity receives for a short time abnormal quantities, the filtrate will not be affected unless such conditions are prolonged. These abnormal quantities are stored in the interstices of the sand grains, but gradually work lower and lower down until they appear in the effluent. With the washing machine as described, long teeth can be used and the sand cleaned thoroughly to any depth such storage has reached, thus furnishing new, clean sand for further storage. Scraping only removes the top surface, leaving anything below to gradually work downward and ultimately reach the filtrate.

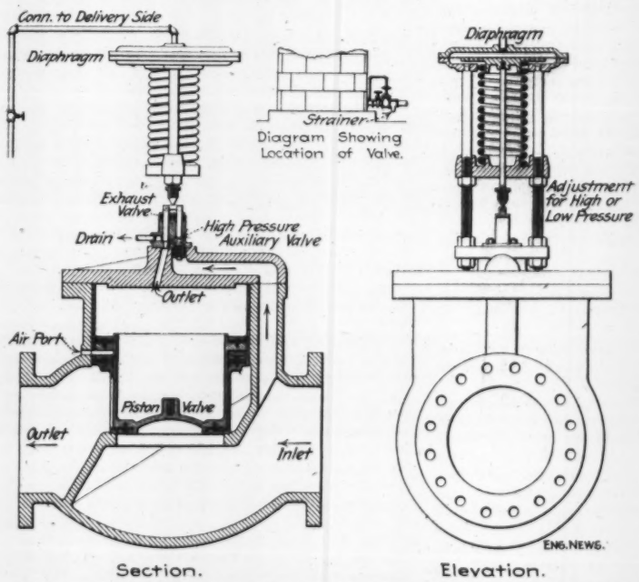
By using a much finer sand than is now the case, much assistance would be afforded toward securing any degree of removal of bacteria or turbidity at any practical rate at the expense of shorter periods between cleanings, but this cleaning is so rapid that the short yield is no longer an element in the problem.

With further experience, it is the opinion of the writer, that much higher rates than 10,000,000 gals. per acre may prove successful, with a corresponding reduction in first cost of construction, thus bringing filtration within the means of many communities now holding back on account of cost.

AN AUTOMATIC VALVE FOR MAINTAINING A CONSTANT HEIGHT OF WATER IN RESERVOIRS AND TANKS.

The accompanying sections show a valve for maintaining a constant level of water in reservoirs, stand-pipes or tanks. As may be seen, the valve requires no float for its operation and may be readily housed to prevent freezing.

The cross-section reproduced herewith shows the main valve, which is of the piston type, closed. Under such a condition, as soon as water is drawn from the tank or reservoir the water pressure on the upper or tank side of the controlling diaphragm is relieved, thus lifting the valve spindle connected therewith and at the same time closing the high-pressure auxiliary valve which controls the passage to the lower or inlet side of the main or piston valve. The same



Section. Elevation.

CONTROLLING ALTITUDE VALVE FOR MAINTAINING A CONSTANT WATER LEVEL IN RESERVOIRS, STAND-PIPES AND TANKS.

spindle-motion opens the exhaust valve, which is alongside the high-pressure auxiliary valve, thus permitting the water which is above the piston valve to escape through the openings provided for that purpose. With the relief of pressure above and the increase of pressure below the piston valve, the valve raises, and air is drawn in through the air port on the left of the upper chamber, thus providing a cushion against closing. The cushion against opening is, of course, provided by the water.

When the water in the tank has reached the standard height, the tank or reservoir pressure reasserts itself on the top of the diaphragm, reversing the operations described.

The valve described, which has been given the trade name of "controlling altitude valve," is made by the Golden-Anderson Valve Specialty Co., of Pittsburg, Pa., to whom we are indebted for the information given.

THE DIAMOND SHOALS LIGHTHOUSE PROJECT is reported to be dead for the present; that is until Congress makes new provision for the work. Capt. A. F. Eels, of Boston, Mass., received authorization from Congress a few years ago to construct a lighthouse on Outer Diamond Shoal, off Cape Hatteras, N. C., where numerous attempts to build a lighthouse have failed. The specified time for him to begin work has expired, however, and no construction work has been done, in the view of the Secretary of Commerce and Labor.

FINDINGS OF THE CANADIAN COMMISSION ON THE QUEBEC BRIDGE.

The report of the Canadian Government Commission of Inquiry on the Quebec Bridge disaster was laid before Parliament at Ottawa March 9. This report is the fruit of five months of remarkably thorough investigation and study, a credit alike to the Canadian government and to the members of the Commission. The Commission is the only body which has had access to all the sources of information necessary for a full analysis of the fatal collapse, and its findings of fact and conclusion are therefore of great interest.

The report reaches us just as we go to press, so that we are able at this moment to present only the findings, which summarize the results of the Commission's work. The bulk of the document is made up of 19 appendices, which set forth in full detail the various facts and conditions concerning the bridge and its construction. Needless to say, the conclusions expressed in these several appendices amplify the formal findings below.

(a) The collapse of the Quebec bridge resulted from the failure of the lower chords in the anchor arm near the main pier. The failure of these chords was due to their defective design.

(b) The stresses that caused the failure were not due to abnormal weather conditions or accident, but were such as might be expected in the regular course of erection.

(c) The design of the chords that failed was made by Mr. P. L. Szlapka, the designing engineer of the Phoenix Bridge Co.

(d) This design was examined and officially approved by Mr. Theodore Cooper, consulting engineer of the Quebec Bridge & Railway Co.

(e) The failure cannot be attributed directly to any cause other than errors in judgment on the part of those two engineers.

(f) These errors of judgment cannot be attributed either to lack of common professional knowledge, to neglect of duty or to a desire to economize. The ability of the two engineers was tried in one of the most difficult professional problems of the day and proved to be insufficient for the task.

(g) We do not consider that the specifications for the work were satisfactory or sufficient, the unit-stresses in particular being higher than any established by past practice. The specifications were accepted without protest by all interested.

(h) A grave error was made in assuming the dead load for the calculations at too low a value and not afterward revising this assumption. This error was of sufficient magnitude to have required the condemnation of the bridge, even if the details of the lower chords had been of sufficient strength, because, if the bridge had been completed as designed, the actual stresses would have been considerably greater than those permitted by the specifications. This erroneous assumption was made by Mr. Szlapka and accepted by Mr. Cooper and tended to hasten the disaster.

(i) We do not believe that the fall of the bridge could have been prevented by any action that might have been taken after Aug. 27, 1907. Any effort to brace or take down the structure would have been impracticable, owing to the manifest risk of human life involved.

(j) The loss of life on Aug. 29, 1907, might have been prevented by the exercise of better judgment on the part of those in responsible charge of the work for the Quebec Bridge & Railway Co. and for the Phoenix Bridge Co.

(k) The failure on the part of the Quebec Bridge & Railway Co. to appoint an experienced bridge engineer to the position of Chief Engineer was a mistake. This resulted in a loose and inefficient supervision of all parts of the work on the part of the Quebec Bridge & Railway Co.

(l) The work done by the Phoenix Bridge Co. in making the detail drawings and in planning and carrying out the erection, and by the Phoenix Iron Co. in fabricating the material, was good and the steel used was of good

quality. The serious defects were fundamental errors in design.

(m) No one connected with the general designing fully appreciated the magnitude of the work nor the insufficiency of the data upon which they were depending. The special experimental studies and investigations that were required to confirm the judgment of the designers were not made.

(n) The professional knowledge of the present day concerning the action of steel columns under load is not sufficient to enable engineers to economically design such structures as the Quebec bridge. A bridge of the adopted span that will unquestionably be safe can be built, but in the present state of professional knowledge a considerably larger amount of metal would have to be used than might be required if our knowledge were more exact.

(o) The professional record of Mr. Cooper was such that his selection for the authoritative position that he occupied was warranted, and the complete confidence that was placed in his judgment by the officials of the Dominion Government, the Quebec Bridge & Railway Co. and the Phoenix Bridge Co. was deserved.

A FIRE IN A COAL MINE in the Hampstead colliery near Birmingham, England, on March 4, resulted in the death of the 26 miners who were in the mine at the time.

A FIRE IN A SCHOOLHOUSE AT COLLINWOOD, Ohio, a suburb of Cleveland, on March 4, resulted in the death of 165 children and two teachers. The building was built seven years ago with brick bearing walls and interior wooden construction. The fire, the origin of which has not as yet been determined, was first discovered in a closet under one of the exit staircases. In response to the fire drill gong all the pupils on the first floor were safely conducted from the building through a wide front staircase, but by the time the second and third floor pupils had reached the main floor the flames at the large entrance were so severe that they were driven to the rear door, an exit narrowed by brick wing walls in the vestibule. At this exit one of the double outswinging doors was bolted and the narrow passage made by this single doorway, together with the outstanding wing walls, soon became choked with panic-stricken children. In this passageway most of the bodies were found, although the fire gained such rapid headway that many were killed before they could reach the exits. There seems to have been but one outside fire-escape and the usual fire drills did not include that as a means of exit.

A BRIDGE WAS WRECKED BY A STEAMER at Toledo, Ohio, on March 6. The "Yuma," a steel freight steamer, was torn from its moorings during a flood in the Maumee River, and was carried against the Cherry St. highway bridge. One span of the bridge was completely wrecked. The Cherry St. bridge was built in 1884, replacing a wooden bridge carried out by flood in 1883. It consisted of six wrought-iron spans, aggregating over 1,000 ft. in length. For some years it has been too weak for the traffic, as a trolley line carrying also heavy interurban cars used the bridge. The municipal authorities provided money for a new bridge over a year ago, but a taxpayers' suit prevented further progress of the replacement enterprise.

BRIDGES UNSAFE UNDER ELECTRIC CAR TRAFFIC are reported from Richmond, Va., and Canal Dover, near New Philadelphia, Ohio. The Free Bridge over the James River between Richmond and Manchester is said to exhibit so much vibration under street cars or the combination of cars and loaded trucks, as to alarm the citizens. The bridge appears to have been in unsatisfactory condition for some years; just three years ago the Mayor's message recommended regular reports on the condition and management of the bridge and plans for future repairs. At Canal Dover, Ohio, a highway bridge used by an electric railway carrying both local and interurban cars has been closed to all but pedestrian traffic as the result of an engineering report that it is dangerous under the heavy cars used.

NEW ISSUES OF TOPOGRAPHIC MAPS of the U. S. Geological Survey, in January and February, 1908, are as follows: Quadrangles newly mapped—Breese, Ill.; Morganfield, Ky.; Minnetonka, Minn.; Ravenna, Ohio; Pomeroy, Ohio and W. Va.; Johnstown, Pa.; El Paso, Tex.; Kenna, Keno, Otter, Walton, W. Va.; and a special sheet for Natural Bridge, Va. Maps of the following quadrangles have been re-issued because the original issues had been exhausted: Kaibab, Ariz.; Sierraville, Cal.; Washington, D. C.; Williston, Fla.; Dunlap, Ill.; Ottawa, Ill.; Betterton, Md.; Newburyport, Mass. and N. H.; Marshall, Mo.; Bayside, N. J. and Del.; Oyster Bay, N. Y. and Conn.; Statesville, N. C.; Millerstown, Pa.; Louden, Tenn.; Morristown, Tenn.; Roanoke, Va. The Washington sheet is sold at 10 cts., the others at 5 cts., by the Director of the Geological Survey.

SUMMARY OF TIMBER-TREATING PROCESSES.

	1905.	1906.	Increase.	Av. amt. in lbs. injected per cu. ft. in 1906.
Creosote—				
Cu. ft. piling	4,545,916	5,353,827	807,911	14
" lumber	2,952,547	3,634,841	682,294	14
" bridge timber	300,041	861,743	561,702	12
" paving blocks	690,769	1,764,233	1,073,464	10 to 14
" crossarms	.....	122,612	122,612	10 to 14
Net increase			3,247,983	
Number of ties treated	1,123,684	1,836,983	713,299	11
Zinc chloride—				
Cu. ft. piling	10,337	11,657	1,320	0.46
" lumber	281,330	365,411	84,081	0.42
" bridge timber	.....	34,887	34,887	0.84
" switch ties	434,655	404,736	*29,919	0.55
Net increase			90,369	
Number of ties treated	13,477,262	14,168,784	691,522	0.43
Zinc and oil—				
Cu. ft. piling	130,610	211,563	80,953	Zinc 0.25 Oil 3.00
Cu. ft. lumber	5,379	5,691	312	Zinc 0.25 Oil 3.00
Net increase			81,265	
Number of ties treated	418,168	918,691	500,523	Zinc 0.38 Oil 2.70
Zinc, glue and tannin—				
Cu. ft. piling	33,778	.....	*33,778	
" lumber	23,860	6,364	*17,496	0.45
" bridge timber	41,692	68,534	26,842	0.45
" switch ties	32,336	37,856	5,520	0.41
Net decrease			18,912	
Number of ties treated	1,399,212	907,775	*491,437	0.50

*Decrease.

THE USE OF TIMBER TREATING PROCESSES in the United States for the years 1905 and 1906 was reported by the Secretary of the Wood Preservers' Association at their annual meeting in Kansas City, Jan. 21-23, 1908. The summary reads as follows:

This table has been summarized as follows:

Net increase cu. ft. of piling	856,406
Net increase cu. ft. of lumber	759,785
Net increase cu. ft. of paving blocks	1,073,464
Net increase cu. ft. of bridge timber	612,837
Net increase cu. ft. of crossarms	122,612
Total increase cu. ft. of material	3,425,104
Net decrease cu. ft. of switch ties	24,399
Total net increase cu. ft. of material treated (not including cross ties)	3,400,705
Total net increase of cross ties treated	1,413,907

GAS IN A TUNNEL of the Pennsylvania R. R. under the city of Baltimore, on March 7, caused the death of four workmen by suffocation and rendered unconscious some twenty others who afterwards revived. The tunnel in which the accident occurred is the most northerly of the tunnels which carry all the allied lines of the Pennsylvania R. R. under the city of Baltimore, extending a distance of 3,600 ft. from Park to Pennsylvania Ave. on the line of Wilson St. It is for two-track travel, and 27 ft. wide with a semi-circular arched opening clearing 22 ft. above the rail elevation. In 1892, some twenty years after the tunnel was built, a ventilating plant was installed, consisting of a fan 15 ft. in diameter placed about midway of the tunnel length and driven by electric power from a central station about a half-mile distant. (Fully described in Engineering News, Oct. 20, 1892, p 362.) Some two or three days before the accident of March 7 this fan was shut down for repairs, but, according to the railway company, this was not an extraordinary occurrence and they had no hesitancy in sending men into the tunnel to perform necessary repairs. However, the gas had accumulated to such an extent that the men were overcome with fatal results to four of them. An interesting conflict of authority arose after the accident when the railway refused to comply with the order of the Baltimore Building Inspector to close the tunnel to traffic until after the fan could be put into operation. Although they did not attempt to explain the deaths of the workmen, the railway authorities continued to send trains through the tunnel on the ground that it was perfectly safe and that the city's building inspector had no jurisdiction. The fan was repaired before the matter became serious and the question of authority has not been settled.

STEAM SHOVEL RECORDS ON THE ISTHMUS were again broken on March 4, when 55,054 cu. yds. of material were removed in eight hours from the Culebra cut. In our last week's issue we reported that the previous record was 50,784 cu. yds. on Feb. 10, 1908.

THE LEFT-HAND RUNNING OF TRAINS on double-track is practiced by two important railways in the United States; the Lake Shore & Michigan Southern Ry. and the Chicago & Northwestern Ry. The practice was in use on the New York terminal lines of the New York Central Ry. and New York, New Haven & Hartford Ry. from 1886 until last August, this having been adopted to facilitate the terminal arrangements approaching the Grand Central Station. After the reconstruction work in connection with the introduction of electric traction on these lines, a change to the usual right-hand system was made on Aug. 25. The Chicago & Oak Park Elevated Ry. has adopted left-hand running, as by the former right-hand system the eastbound and westbound trains had to cross each other at the connection with the elevated loop terminal.

PANAMA CANAL WORK during February, as noted in our last issue, exceeded, in place measurement, all previous records. The detailed figures for January and February, 1908, are given below:

Steam Shovels.	Feb. 1908. cu. yds.	Jan. 1908. cu. yds.
Culebra Division	1,176,752	1,150,334
Gatun Locks	176,221	193,567
Mindi, Chagres and Miraflores.	304,440	239,485
Dredges.		
Colon Division	401,967	444,403
La Boca Division	682,271	460,250
Total Canal Prism	2,741,651	2,488,039
Accessory works outside the canal prism	204,230	224,529
Total Excavation	2,945,881	2,712,568

There were only 24 working days in February, thus making the daily average excavation 122,745 cu. yds. against a daily average of 104,330 cu. yds. during the 25 days of January. The rainfall during February dropped to 0.43-in. The total amount of earth excavated from the canal zone from the beginning of the American occupation to March 1, 1908, is 28,414,934 cu. yds.

A SUSPENDED MONO-RAIL RAILWAY is projected in Berlin, Germany, traversing the city from east to west through the residence and business sections. Instead of the construction used for the Barmen-Elberfeld line, on which the supporting structure is a series of A frames, the Berlin project proposes a series of columns in the middle of the street carrying cantilever beams supporting longitudinal trusses on each side. This center line of posts serves to divide the street traffic and also leaves a zone of refuge which may be used for cab-stands and the like.

A UNION PASSENGER STATION FOR SAN FRANcisco is proposed. This project is being exploited by the Ocean Shore Ry. Co., which is now building a line from San Francisco down the coast to Santa Cruz and which has already procured options on most of the property involved. The new station is to be located in the block bounded by Market, Mission, Eleventh and Twelfth Sts. and will face on Market St. at the intersection of Van Ness Ave., the location picked out for a civic center by Mr. D. H. Burnham in his Report on the Improvement and Adornment of San Francisco. At this point the main steam railways are to terminate in 16 tracks which are to be carried for some four blocks over the city streets on viaducts from a point near Bryant and Division Sts. near which all the steam roads entering the city now pass. This same viaduct is also to carry all the interurban electric lines, but a low grade level in the station is to be provided for these lines so as to avoid conflicts between the interurban and through passengers. Another part of the scheme calls for large reinforced-concrete warehouses all along the line of the viaduct, to be used for storage by the local merchants and to be connected with and under the control of the terminal company. This plan is the work of Mr. John B. Rogers, Chief Engineer of the Ocean Shore Ry. The details yet remain to be perfected and a great amount of study has yet to be put upon the scheme before it can be fully decided upon.

A REVERSAL OF THE FLOW OF THE CHICAGO River was caused by heavy rainfall and melting snow on March 6, so that instead of all of it discharging through the drainage canal some of it went that way and some of it into Lake Michigan, thus endangering the water supply of Chicago. Orders were at once given to open the bear trap dam at Lockport, so as to increase the discharge through the drainage canal from 250,000 to 600,000 cu. ft. per sec. The Commissioner of Health gave prompt notice to citizens that all water for drinking and allied purposes ought to be boiled.

A 160-FT. SPAN TRUSS BRIDGE across the Mississinewa River at Marion, Ind., collapsed on March 1, fortunately when no one was crossing. The river had been very high for some days previous and although the wreckage is so complete and the water so swift that no exhaustive examination can be made, it is thought that the accident was due to the undermining of the foundations. The bridge of which the collapsed span formed a part consisted of two 160-ft. spans resting on concrete abutments and a pier. It had been built in 1904 under supposedly safe specifications and was considered amply safe to carry any load to which it might be subjected.

SEPTIC TANK PATENT litigation promises to continue. Authorized representatives from a score or more cities in several States met at Harrisburg, Pa., on March 9 and formed a permanent organization for the purpose of carrying on litigation in the matter of the Cameron Septic Tank patent upon which a decision was rendered last January by the Circuit Court of Appeals of the 2d District and also of resisting the payment of any royalties by any of the interested cities throughout the life of this patent. The executive and finance committee elected at this meeting is as follows: Chairman, F. Herbert Snow, Chief Engineer, State Dept. of Health, Pennsylvania; Secretary, R. W. Pratt, Chief Engineer, State Board of Health, Ohio; Treasurer, G. A. Johnson, Consulting Engineer, New York; Wade Ellis, Attorney General, State of Ohio; T. C. Hatton, Consulting Engineer, Wilmington, Del.; G. E. Hill, Consulting Engineer, New York; R. A. Cairns, City Engineer, Waterbury, Conn.

A DAM ACROSS THE ST. LAWRENCE RIVER near Cornwall, Ont., and Massena, N. Y., with an attendant power plant, is a project to be reported to the Canadian branch of the International Waterways Commission by a special committee appointed by the Canadian Government. This scheme had its inception some years ago when the companies drawing power from the opposite sides of the river at this point proposed to join forces and erect a large plant which comprised a dam 3,700 ft. long and 40 ft. high and a very high lift lock which would replace the numbers of smaller locks in this vicinity. Although it was claimed that distances would be shortened and navigation made easier by this construction, the proposed destruction of the picturesque Long Sault Rapids led many organizations on both sides of the river to protest against the scheme to their respective governments and the required permission was not given to the companies involved. Finally the subject came up before the International Waterways Commission, the Canadian section of which has referred the matter to the committee noted above.

THE U. S. S. SCOUT CRUISER "CHESTER," whose new speed records we briefly noted last week, showed up surprisingly well in her long distance trials which ended March 4. The "Chester" made an average speed of 22.8 knots per hour on a 24-hour coal consumption trial and an average speed of 26.52 knots per hour over a four-hour trip. Both of these figures are records for naval vessels of 1,500 tons or over. Beside breaking these speed records she showed remarkable fuel economy, using, on the 24-hour trial, only 0.15 tons per knot covered. As her bunker capacity is 1,250 tons, this rate would give the cruiser a steaming radius of 8,250 miles. This cruiser is one of three of similar type which the government has now under contract. Each boat is of 3,750 tons displacement, with an indicated horse-power of 16,000. The "Chester" is equipped with Parsons' turbine engines, one of the other two is to be fitted with Curtiss turbines and the third with reciprocating engines, so that a thorough test of the advantages of each type of engines can be made by the government.

PERSONALS.

Mr. J. W. Leonard has been promoted from Assistant General Manager to General Manager of the eastern lines of the Canadian Pacific Ry.

Mr. F. C. Finkle, consulting engineer, has removed his offices from the Edison Building to the I. W. Hellman Building in Los Angeles, Cal.

Mr. B. M. Hall, lately of the U. S. Reclamation Service, has gone to Porto Rico to take charge, as chief engineer, of the irrigation work there.

Mr. Arthur West, M. Am. Soc. M. E., who has been until recently Chief Engineer of the Westinghouse Machine Co., has become manager of the power department of the Bethlehem Steel Co.

Mr. E. C. Bagwell has resigned as Assistant Engineer on the Seaboard Air Line Ry. and has become Superintendent for the Charlotte Harbor & Northern Ry., with headquarters at Hull, Fla.

Mr. Ernest W. Wiggin, Assoc. M. Am. Soc. C. E., has resigned as Engineer of Bridges and Buildings with the Missouri Pacific Ry. to become Superintendent of Bridges and Buildings of the New York, New Haven & Hartford R. R.

Mr. George Loughnane has been appointed Division Engineer of the Peninsula Division of the Chicago & Northwestern Ry. Co., with headquarters at Escanaba, Mich., and Mr. J. A. S. Redfield has been promoted to succeed Mr. Loughnane as Division Engineer and Foreman Bridges and Buildings of the Iowa & Minnesota Division of the same road. Mr. Redfield will be located at Mason City, Iowa.

Obituary.

Benedict C. Smith, who was for over 30 years Superintendent of Bridges and Buildings of the Toledo & Ohio Central Ry., died at his home at Fostoria, O., on March 6. At the time of his death Mr. Smith had retired from the office which he had so long held, but was acting as inspector in the same department.

George E. Thomas, M. Am. Soc. C. E., died on March 6th at his residence in New York City, at the age of 66 years. Mr. Thomas was regarded as an expert on sub-aqueous work, to which class of engineering he devoted nearly forty years of his life. To his skill is largely due the adoption of the pneumatic caisson process of preparing the foundations for large buildings for he was in charge of the first work of this character, which was in the construction of the Manhattan Life Building in New York City. Of late years Mr. Thomas was engaged in building construction, and among other works supervised the construction of the Subway Power-House on 59th St., and the City Investing Building on Cortlandt St., both in New York.

James Dun, M. Am. Soc. C. E., Consulting Engineer of the Atchison, Topeka & Santa Fe Railway system, died suddenly at St. Augustine, Fla., Feb. 23, as was noted in our issue of Feb. 27. He was born at Chillicothe, O., in 1844, and was educated at the public schools and at Miami University. Beginning his railway service as a chainman on the Indianapolis & Cincinnati Ry. in 1866, he became Assistant Engineer of the Atlantic & Pacific Ry. in 1867, and of the Missouri Pacific Ry. in 1877, when he went to the St. Louis & San Francisco Ry. as Superintendent of Bridges and Buildings. He became Chief Engineer of the St. Louis & San Francisco Ry. in 1878, and filled this position until 1890, at which time he became Chief Engineer of the Atchison, Topeka & Santa Fe Ry. In 1900 he was made Chief Engineer of the entire Santa Fe system, with headquarters in Chicago. Since September, 1906, he had been Consulting Engineer of the same road. In the course of his life as chief engineer of various railways, extending over a long period of time, Mr. Dun was in charge of many important pieces of work and had a very large circle of acquaintances among engineers. He was a member of the American Society of Civil Engineers, the Western Society of Engineers, the American Railway Engineering and Maintenance of Way Association (of which he had been a Vice-President), and the St. Louis Society of Engineers. He was also a member of the Chicago and Onwentsia clubs. Mr. Dun had been twice married, his second wife being Mrs. Lucy J. Rucker, to whom he was married in 1899, and who survives him. He leaves one daughter.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 17-19, 1908. Annual convention at Chicago, Ill. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago.

AMERICAN RAILWAY ASSOCIATION.
April 22, 1908. Semi-annual session at New York City. Secy., W. F. Allen, 24 Park Place, New York.

AMERICAN ELECTROCHEMICAL SOCIETY.
May 1-2, 1908. Annual meeting at Albany, N. Y. Secy., Joseph W. Richards, Lehigh University, South Bethlehem, Pa.

AMERICAN WATER-WORKS ASSOCIATION.
May 11-16, 1908. Annual meeting at Washington, D. C. Secy., John M. Diven, 14 George St., Charleston, S. C.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 23-26, 1908. Annual convention at Denver, Colo. Secy., C. W. Hunt, 220 West 57th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
June 23-26, 1908. Annual convention at Detroit, Mich. Secy., C. W. Rice, 29 West 39th St., New York City.

INTERNATIONAL UNION OF STREET RAILWAYS AND LIGHT RAILWAYS.—The date of the 15th Congress has been set for Sept. 7, 8 and 9, the meeting being held at Munich, Germany. The list of subjects has already been given in our columns.

CANADIAN MINING INSTITUTE.—At the regular annual meeting at Ottawa, March 6, the following officers were elected: President, Dr. W. G. Mill, of Toronto; Treasurer, Mr. J. Stevenson Brown of Montreal, and Secretary, Mr. H. Mortimer Lamke of Montreal.

ARKANSAS POLYTECHNIC SOCIETY.—The society was organized in December, 1907, and has about 85 members. It will hold meetings every month except June to September (inclusive). President, Fred Williams, Little Rock, Ark. Secretary, Alfred Lund, Civil Engineer, 211 W 2d St., Little Rock, Ark.

ENGINEERS' CLUB OF CENTRAL PENNSYLVANIA.—At the last annual meeting the following officers were elected: President, Mr. Wm. P. Mackenzie; 1st Vice-President, Mr. F. Herbert Snow; 2d Vice-President, Mr. Robert J. Walton; Treasurer, Mr. Charles M. Mercer and Secretary, Mr. William Dill. The club has just moved into a new home at 219 Market St., Harrisburg, Pa.

WESTERN SOCIETY OF ENGINEERS.—At the meeting held at the Society's rooms in Chicago on March 4, Mr. Geo. M. Brill presented a paper on "The Location, Arrangement and Construction of Manufacturing Plants," illustrated by numerous stereopticon views of buildings of different types for plants of this kind. The paper discussed the topographical and geographical conditions, transportation facilities, and the general design and arrangement of buildings, together with questions of heat, light, fire protection, and provision for the comfort and convenience of employees.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—At the meeting of March 4, at the house of the society, the subject of discussion was a paper by Mr. R. S. Chew, entitled "Effect of Earthquake Shock on High Buildings." The paper represents an attempt to determine by approximate mathematical analysis the nature of earthquake action on buildings. The author concludes that the action is similar to wind action, but is a function of the weight and the stiffness, so that buildings should be as light and as flexible as possible. The author's opinion appears to be against reinforced concrete for high buildings. Mr. G. B. Waite in a written discussion attacked this latter view, but without analyzing earthquake effect. Mr. E. W. Stern spoke at some length on earthquake-resistant construction, raising the question of what intensity of earthquake is to be provided for, and whether in the case of regions that are seismically far more powerful than California it would not be primarily necessary to limit the height of buildings. In discussing details of construction he discussed some features of the construction of the Lackawanna ferry-house at Hoboken, N. J. (Eng. News, Sept. 20, 1906, p. 297), where, in order to provide against the shock of landing ferryboats, he was compelled to design virtually on an earthquake basis.

More important than the paper, perhaps, was the adoption of a resolution moved by Mr. L. D. Rights, to the effect that the society appoint a committee to investigate the subject of steel columns in structures and report on their design, ultimate strength and safe working values. The matter now goes to the society's Board of Direction for consideration.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Mr. Charles P. Steinmetz read a paper on "The Steam Path of the Turbine," at the society's regular meeting at New York on March 10. The paper is a mathematical study of steam expansion and steam flow, using algebraic methods. Various details of the analysis and its underlying assumptions were strongly questioned in the discussion, by Mr. H. E. Longwell (Pittsburg, Pa.), Mr. Strickland L. Kneass (Philadelphia, Pa.), Prof. S. A. Reeve (New Haven, Conn.), and Prof. C. H. Peabody (Boston, Mass.). Mr. Longwell mainly criticized the expressions for steam energy and the specimen calculations from these equations, and showed results calculated by the customary methods which differed considerably from Mr. Steinmetz's figures. The same point was also raised by Prof. Peabody, in a letter, who also contended that the proposed method of making steam calculations required to be shown as correct as the present method and also to be more useful or more convenient. He further criticized the assumption that specific heat of superheated steam does not vary with temperature, while Thomas' and Knoblauch & Jakob's tests showed temperature to have a decided influence. The high nozzle efficiencies of 97 to 98% given by the author were also questioned. Mr. Kneass, besides several criticisms in detail, raised strong doubt of the assumption that the expansion of steam in a nozzle follows the adiabatic law; he held that the appearance of a transparent zone at the base of a jet from a nozzle shows that the expansion cannot be adiabatic. Prof. Reeve advanced various mathematical objections to the analysis given by the author. Mr. Steinmetz made more or less complete answer to all these criticisms. The objections dealing with nozzle efficiency and with specific heat of superheated steam he answered by referring to elaborate experimental work done by the General Electric Co. This work on specific heat of superheated steam is presumably that presented by Mr. A. R. Dodge a year ago before the society.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, March 12, 1908.

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CORRESPONDENCE.

Criticism of the Review of Balet's "Analysis of Elastic Arches."

Sir: A review of my book "Analysis of Elastic Arches," was published in your issue of Feb. 20, 1908. While it gives a fair description of the contents, some of the comments made seem to be incorrect or immaterial. Concerning the reviewer's criticism of the author's style, it should be said that repeated use of the book will make the reader thoroughly conversant with the new method of composing and resolving forces introduced by the author, and when this is familiar the author's style will be found clear.

The treatment of the three-hinged arch is properly included because, while the three-hinged arch is not an elastic arch, the analysis of its stresses affords the opportunity of presenting the author's method of compounding forces in a simple manner. For the other arches the work is more involved, and therefore, to be well understood, it is first presented in its simplest form, and the reader is there prepared to apply it in all its axiomatic truth to more complex problems.

The reviewer's criticism of an equation on p. 259 is incorrect. In applying this equation it should be remembered that it was deduced from eq. (16), and for the semi-circular arch the approximation indicated at the foot of p. 258 would involve too large an error. The expansion and contraction act along and in the direction of the arch axis. This makes its direction vertical at the hinges, and when the secondary stress is neglected, the horizontal thrust from this cause is zero. [! Ed.] The secondary stress, however, in such an arch (caused by a change in temperature) may be considerable, as it depends on the sectional form of the arch rib. A better way might, perhaps, have been to repeat the equation for this special case, indicating the limits of integration as b and 0, or the foregoing explanation might have been inserted in the book; but the author deemed it of so little importance that he omitted both, as the careful student can draw his own conclusions.

The practical solution of wind stresses is fully described on pp. 207 to 211 for the three-hinged, the two-hinged, and the hingeless arch. When once the intensity of the horizontal and vertical forces L and V of Fig. 47b, P. 210, is found, the procedure then follows the same lines as shown and described for the two-hinged arch (which is given in detail for the crescent-shaped arch, see plate facing p. 82) and for the hingeless arch (see paragraph 3, p. 118, also pp. 120, 121, etc.). If it is the idea of the reviewer that the computation of stresses in an arch acted on by lateral forces (assuming the whole structure to be a curved beam), should have been introduced, the author's opinion is that while this may be interesting as an academic proposition, it is too involved for practical use, and considering that the intensity of the wind pressure is an uncertain quantity, the simple and direct methods indicated in the book are sufficient and accurate.

Any engineer who will apply the methods of correction of the intersection locus and the tangent curves, and check them by the use of the general theory, in the manner shown in the book, will thereafter have implicit confidence in these corrections. It will show him that they are not confined to the rates of variation of the cross-sections which have been used in the examples; they are general in their application. He will also be thoroughly convinced that they are simple and reliable for the computation of stresses in the two-hinged arch, and that they give the only workable method so far evolved, either in this country or in Germany, to compute the stresses in the hingeless arch with absolute certainty and simplicity for varying forms of loading.

J. W. Balet.

New York City, March 4, 1908.

REVIEWS.

The National Civic Federation Report on Municipal and Private Ownership.

MUNICIPAL AND PRIVATE OPERATION OF PUBLIC UTILITIES.—Report to National Civic Federation Commission on Public Ownership and Operation. In Three Volumes. New York: National Civic Federation. London, England: Agents, P. S. King & Son. Cloth; 6 × 9 ins.; tables. $10 for the three volumes; Part I. sold separately at $2 in cloth and at $1 in paper.

Part I., Vol. I.: General Conclusions and Reports. Pp. 489.

Part II., Reports of Experts: Vol. I., United States; pp. 1,230. Vol. II., United Kingdom; pp. 768.

These ponderous volumes on municipal and private ownership are far superior to anything of the kind heretofore published. Although of more general and vital interest, they yet resemble in some respects reports of trials of important law cases in the courts. There are some 2,000 pages of testimony, some hundreds of pages of briefs and arguments by the opposing sides, and a very few pages of opinion or decision based on the testimony and arguments submitted. The testimony, however, is different from that in most law cases in that it consists solely of the results of special investigations by experts in four well-chosen fields, the experts following the lines marked out by the judges and the data submitted being for the most part of a very impartial character. A further and important difference which may be noted is that in addition to the briefs and arguments of the opposing sides there are, if they may be so called, a number of briefs on special topics, prepared with a marked degree of impartiality.

As many of our readers know, the investigation here reported was entered upon some two years ago by a committee selected by the National Civic Federation. The original committee consisted of 21 members, some favorable to, some opposed to, and some neutral or with an open mind on, the question of municipal ownership. The members of the committee were chosen from various walks of life and included officials of both publicly and privately-owned municipal service industries, besides editors, college professors and leading representatives of labor organizations. The general plan of investigation was as follows: An equal number of publicly owned and privately owned water-works, gas works and electric light works in the United States, and the same in Great Britain (with the exception that in Great Britain water-works were omitted and tramways were added) were selected for detailed examination and comparison. So far as feasible, the members of the Committee of Twenty-one were to visit the several plants, but the main work of detailed investigation was to be entrusted to four groups of experts: the first group to deal with general historical and legislative matters; the second with organization, labor and politics; the third with engineering topics; and the fourth with finance and accounting. The data thus collected were to be submitted to a subcommittee for digestion and comment, and finally the whole committee was to draw its conclusions from the information in hand.

The plan outlined was followed pretty closely, with the exception that no investigation whatever was made of the four private American electric light plants nor of some of the other American private plants nor of one of the British private tramway systems selected for the purpose, and in addition the finances and accounting of such American private plants as were investigated were not gone into at all.

As a result of dropping so many of the American private plants and omitting a financial investigation of those that were left, the American work was greatly curtailed in scope and in value. In fact, so far as comparative financial operations and relative cost of service under municipal and private ownership are concerned the American part of the investigation and report is a complete failure.

The data presented by the expert investigators are so voluminous as to be beyond use by more than a few specialists, and even specialists must have plenty of time available if they make further use of the data than reference on special points. This fact was recognized by the committee and accordingly it aimed to digest the data in the way already stated. The digest, together with the results of special investigations outside of those made by the four groups of field experts, as they may be called, forms a readable volume of nearly 500 pages. The portions of this volume which we have already characterized as being comparable with lawyers' briefs and arguments are, for the most part, of a decidedly partisan character. One wholly unfamiliar with the pros and cons of municipal ownership might, on reading either side as here stated, conclude that there was nothing left in support of the opposite side. Where each side to a controversy can make out so good a case, there is evidently much to be said on both sides, and the need for a judicial opinion on the merits of the case is great. On this account, it is to be regretted that the general review of the whole investigation contains so little in the way of judicial weighing and balancing. It is true, as we have already stated, that there are several remarkably fair and impartial reviews of special phases of the investigation, but what one most wishes for is entirely absent: namely, a thoroughly judicial weighing of all the evidence in favor of and against municipal ownership so ably presented by the two sides of the subcommittee on evidence.

The brief conclusions of the Committee of Twenty-one, or so many of the committee as joined in the report, do not meet this need, because they are quite general in character and deal only with broad questions of public policy. They might be characterized as a court decision without the supporting opinion. Perhaps no more than this could be expected, in view of the complexity of the subject and the mass of data. But a great service would have been rendered had some competent person or persons taken in hand the two opposing partisan reviews of the data and shown which of the contentions of each side is worthy of belief. As it is, diametrically opposite conclusions are now drawn from the same facts.

The general conclusions of the main committee, with the names of the committeemen, were published in Engineering News of Aug. 15, 1907, and in the same issue there appeared editorial comment on the conclusions. It is therefore unnecessary for us to say anything further on this topic except to repeat that it is remarkable that 17 of the 20 men who joined the report could have agreed on so many of the points at issue in the vexed question of municipal and private ownership. Perhaps we may add, for the convenience of our readers, that 19 men agreed that municipal ownership is largely a question of local expediency, but that at the same time it has so many drawbacks, particularly under the unfortunate conditions that are so prevalent in American municipalities, as to make conservatism in entering on municipal ownership desirable. The 19 also agreed that where municipal undertakings are entrusted to private companies those companies should be under efficient public regulation.

Obviously it would be impossible to discuss here the details of the 2,000 pages of this report which give the results of the work done in the field by the four groups of experts already mentioned. Many of our readers, however, will wish to know who these experts were and what cities they studied. The general history, franchises,

etc., of the various undertakings were reported on by Prof. John H. Gray, of the University of Minnesota; labor and politics were entrusted to Prof. John R. Commons, of Wisconsin University, and Mr. J. W. Sullivan, editor of "The Clothing Trades Bulletin," New York City, the first chosen as being generally in favor of municipal ownership and the second of private ownership; waterworks engineering was handled by Mr. Dabney H. Maury, M. Am. Soc. C. E., Chief Engineer of the Peoria Water Co.; gas engineering, by Mr. Alfred E. Forstall, M. Am. Soc. M. E., 58 William St., New York City, and Mr. Frederick Burnett; the engineering of electric lighting plants, by Mr. Charles E. Phelps, Jr., Assoc. Am. Inst. E. E., Chief Engineer Baltimore Electric Commission, Baltimore, Md., and Mr. Theodore Stebbins, M. Am. Inst. E. E., of J. G. White & Co., 43 Exchange Place, New York City; financial and accounting matters, Marwick, Mitchell & Co., Chartered Public Accountants, 79 Wall St., New York City. In addition, electric lighting plants in Massachusetts were investigated by Messrs. Charles E. Pritchard and Alton D. Adams, M. Am. Inst. E. E., the last-named of Worcester, Mass.

For the foreign cities, Dr. Milo R. Maltbie, now a member of the Public Service Commission of New York City, took history, franchises, etc., and Professor Commons and Mr. Sullivan handled labor and politics. Mr. William Newbigging, a well-known consulting gas engineer of Manchester, England, and Mr. J. B. Klumpp, Assoc. Am. Inst. E. E., one of the engineers of the United Gas Improvement Co., of Philadelphia, handled gas. Mr. A. E. Winchester, M. Am. Inst. E. E., formerly engineer of the municipal electric lighting plant of South Norwalk, Conn., dealt with electric light and power. Mr. Norman McD. Crawford, Assoc. Am. Inst. E. E., of Hartford, Conn., and Mr. J. H. Woodward, of Preece & Cardew, London, were the engineers for tramways investigation. Mr. R. C. James, Accountant of the United Gas Improvement Co., of Philadelphia, and Mr. E. H. Turner, Chartered Accountant, Manchester, England, dealt with the accounts and finances of all the foreign undertakings.

The American cities investigated were as follows:— Gas: *Public*, Wheeling, W. Va., Richmond, Va.; *Private*, Atlanta, Ga., Norfolk, Va., Philadelphia, Pa. (special phases).

Water: *Public*, Cleveland, O., Chicago, Ill., Syracuse, N. Y.; *Private*, New Haven, Conn., Indianapolis, Ind.

Electric light and power: *Public*, Chicago, Ill., Allegheny, Pa., South Norwalk, Conn., Detroit, Mich. In addition, eight public and eight private Massachusetts electric light plants were investigated, but the reports on these are not considered in the general discussion of the first volume.

The original plan contemplated investigating the private water company at Utica, N. Y., but the company first declined to permit an investigation, and when it consented the time available for field work was insufficient for the purpose. The original plan also included an investigation of private electric light plants at Chicago, Ill., Pittsburg, Pa., Geneva, N. Y., and Toledo, O., but it appears to have been concluded that the differences between the governing conditions of these private plants and the municipal plants selected were so great as to render comparisons of no value, and the private plants were therefore dropped from the consideration. It may perhaps be stated here as well as anywhere that of the municipal electric light plants investigated the one at South Norwalk alone supplies commercial light, and the population of this place is considerably below 10,000.

The foreign undertakings investigated were as follows:—Gas: *Public*, Glasgow, Manchester, Birmingham and Leicester; *Private*, London (South Metropolitan Gas Co.), Newcastle, Sheffield.

Electric light and power: *Public*, Glasgow, Manchester, London (Borough of St. Pancras), Liverpool; *Private*, Newcastle (two companies), London (four companies).

Tramways: *Public*, Glasgow, Manchester, Liverpool, London (Southern System of County Council); *Private*, Dublin, Norwich, London (United Tramways Co.). The company at Bristol was also chosen for investigation, but, like the water company at Utica, N. Y., it refused consent until it was too late to take it up.

The various groups of experts were provided by the main committee with very elaborate schedules, as may readily be supposed from the size of the volumes required to print their findings. In printing these reports, much greater clearness and ease of reference would have been secured had they been somewhat differently arranged. The arrangement followed was to print a question and then give answers in succession for each of the cities. Inasmuch as many of these answers were in the form of text and some of the answers extended over several pages, the method followed proves to be very inconvenient. It would have been much better in many respects if each city had been dealt with separately, except in so far as the data admitted of tabulation. The use of catch subheads at the tops of the pages would have greatly facilitated the use of these volumes. As it is, they merely have such general main page-heads as "Electricity Finance."

The reader may have noticed that for some of the special lines of field inquiry there was but one expert, whereas in others, and generally, there were two. This is explained by the fact that in some cases the municipal and the private ownership sides agreed on a single investigator, although the general plan pursued was to have each side choose its man. As we have already intimated, the findings reported by the experts are generally impartial in character. This is true, whether they are the joint findings of men chosen, one each by the two sides, or the findings of a single man agreed to by both sides. Where exceptions may be taken to the impartiality of the field experts they relate more particularly to some of the many questions which could be answered only by drawing largely or wholly on personal opinions rather than on facts; or the exceptions as to impartiality relate to questions difficult to answer because information could be obtained only with difficulty, if at all. For example, Mr. D. H. Maury had to answer many questions of the sort just described. As an expert agreed on by both sides absolute impartiality was to be expected from him, and in this respect most of his answers are eminently satisfactory. But we seem to detect what we are sure is a wholly unintentional tendency on Mr. Maury's part to be a little more ready to find an explanation for any weaknesses, real or apparent, in private than in municipal water-works. This is particularly true of (1) matters relating to the purity of the supplies furnished and (2) the effect of deficiencies in the water-works upon fire insurance rates. In some of the statements (pp. 217 to 223, Part II., Vol. I.) it hardly seems as though the character of the water supplies and the typhoid death rates of the various cities had been adequately correlated. To have done this, however, might have required more time than was available for a single phase of the investigation. But perhaps the strongest criticism to be made of Mr. Maury's data, particularly in view of its use by Messrs. Clark and Edgar, as noted farther on, is his expression of *belief* that 80 to 90% of the cost of the Chicago Drainage Canal is properly chargeable against the cost of the Chicago water-works. We shall revert to this matter.

Two noteworthy special papers in the volume devoted to reports of experts relate exclusively to the Philadelphia gas works. In one of these reports Mr. Walton Clark, of the main committee, and also a vice-president of the United Gas Improvement Co., which now operates the Philadelphia works under a lease, contrasts the personnel of the works under municipal and under private management. The most ardent believer in municipal ownership could not deny that, as regards personnel, the picture is bright on the private and dark on the municipal side. Fortunately for the *whole* truth about these works, Prof. Leo S. Rowe, in the second of the two special papers named, exhibits the dark side of private manipulation, in league with political bosses to cripple the municipal works so they might be turned over to private management and profit. At the same time Professor Rowe brings out many a fact damning to municipal ownership—of the one-time Philadelphia sort. In conclusion, he makes the following telling comment on the notorious attempt to extend by 50 years the lease of the city gas works to Mr. Clark's own company:

> It is not likely that there would have been the slightest agitation for the termination of the lease in force had it not been for the unfortunate proposition submitted by the company in May, 1905, for the further extension of the lease until the 31st of December, 1977. It is not within the province of this monograph to discuss the details of the proposal nor the influences back of it. To what extent the hands of the company were forced by unscrupulous politicians will probably never be disclosed. Suffice it to say that the proposition passed both branches of councils and though vetoed by the mayor would have been passed over his veto but for there not been an upheaval of popular indignation which brought the city to the verge of riot and disorder.
>
> This incident has had a curious effect on the public opinion of the community. It has developed a distrust of the influence of public service corporations in the civic life of the community. Whereas prior to the recent agitation the people pointed with a certain local pride to the United Gas Improvement Co., there is now prevalent a keen sensitiveness to the dangerous political influence which such a corporation can exercise. Whether justified or not, the existence of this feeling is likely to have no inconsiderable influence on the future relation of the city of Philadelphia to the gas supply.

The remainder of our remarks will refer to the first volume of the three, which gives the general conclusions and reports. This volume opens with a general introduction by Mr. Edward A. Moffet, of Indianapolis, and with papers by Mr. Walter L. Fisher, of Chicago, and Prof. Frank J. Goodnow, of New York City. Mr. Fisher deals with the American and Professor Goodnow with the British municipality. Mr. Fisher's conclusions as to the relation of the American city to municipal ownership are cautionary but by no means condemnatory. He points out that other than purely business reasons and low costs must govern the municipal service, especially the good of the whole community. Professor Goodnow, in his conclusions, states that it is doubtful whether municipal ownership in Great Britain could have obtained its present position under other than the peculiar conditions there prevailing. He adds that if city administration there was not free from politics and the spoils system then municipal ownership, as compared with what it is now, would be inefficient and a source of loss. In the light of these facts, for municipal ownership to be successful in the United States would necessitate a considerable change in the conduct of our city government. From the last statement, one might get the idea that very little municipal ownership exists in the United States, whereas more than half the water-works and a fifth of the electric lighting plants fall in that class.

Both Mr. Sullivan and Professor Commons appear in this volume for the purpose of digesting and commenting on their own field-work reports, as given in the other two volumes. Mr. Sullivan, under the heading, "The Labor Report," presents a study which is valuable both for the facts and opinions recorded and as re-

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flecting the thoughts and conclusions of a trades unionist man. He regards municipal ownership as decidedly unfavorable to organized labor, and also to labor in general and the community at large. He certainly makes an argument which on its face is strongly against municipal ownership. But whatever unfavorable impression may be left in an impartial mind after reading Mr. Sullivan's report is largely removed by reading what Professor Commons says, immediately afterwards, on "Labor and Politics." This investigator and commentator is a friend alike of organized labor and of municipal ownership, and sees in the latter benefit rather than injury to the former. The attitude that he sets up as his ideal in writing his summary, is best expressed in his own words:

. . . I cannot, as an offset to the summary prepared by my colleague, confine myself simply to the facts that discredit private ownership and exalt municipal ownership, but I must summarize all of the facts.

This is not only commendable, but Professor Commons' report gives evidence of no little success in an honest and earnest attempt to present both sides of the case.

The battle royal centers in two groups of discussions. The first group is given the general heading, "Municipal Operation *versus* Private Operation of Municipal Monopolies." The thesis is the superiority of municipal ownership. The writers and sub-topics are: Prof. Frank Parsons, who introduces the subject; Mr. E. W. Bemis, Superintendent of Water-Works, Cleveland, O., who reviews American conditions; Mr. Milo R. Maltbie, who deals with gas and electric works in Great Britain; and Professor Parsons again, who treats of British Tramways. The second and opposing group presents an "Analysis and Interpretation of the Information Concerning Municipal Ownership of Public Utilities," which is the joint production of Mr. Chas. L. Edgar, President of the Edison Electric & Illuminating Co., of Boston, Mass., and Mr. Walton Clark, already several times mentioned. This group of papers also includes one on "British Tramways," by Mr. Wm. J. Clark, General Manager of the Foreign Department of the General Electric Co., New York City. Of the three men in this group Messrs. Edgar and Wm. J. Clark dissented from some of the most important of the "General Conclusions" embodied in the report of the main committee, and Mr. Walton Clark put in a strong anti-municipal ownership minority report.

A volume might and really ought to be written on these two groups of reports—reports drawing such conflicting conclusions from supposedly identical data. Such a volume would do what was pointed out at the opening of this notice as highly desirable: give a judicial review of the arguments and assertions made by the two sides. Until such a volume is written we shall take pleasure in recommending that the reports themselves be read and that the readers draw their own conclusions as best they may. Even if a judicial summary of the evidence were available the for-the-most-part partisan discussions pro and con deserve wide and careful reading. for they exhibit, as a strictly judicial review of testimony could hardly do, the dangerously weak points and also the many strong points of both municipal and private ownership.

Never before have the assertions on the two sides of the municipal ownership controversy been backed by such a wealth of specific illustrations, and never before has so much ingenuity been exhibited in magnifying all the good points and belittling or disproving all the bad points brought to light. Particular attention should be directed to the analyses and summaries of the finances and financial operations of municipally-owned waterworks. To begin with, the schedules were carefully framed with the object of bringing to light the many important cost-elements so commonly omitted from municipal accounts. The accountants presented not only the book values of several plants and the book charges against and in favor of them, but also such ignored or inadequately allowed items as depreciation and services rendered to or by other departments. Unfortunately, company finances instead of being so ruthlessly exhibited as are municipal shortcomings, are not given at all; that is, in the case of American undertakings. In view of this failure, Messrs. Clark and Edgar might be expected to temper their comments on the shortcomings of American municipal accounts and to make fewer flings at the reliability of the British municipal accounts and finances. They descant on the meager depreciation allowances of municipalities, without even so much as a hint that the British companies investigated follow no standards in this particular, while American companies, as a rule, seem to have no standards of the sort to follow.

Of the various writers in each of the two groups it seems to us that Mr. Maltbie, to take first those supporting municipal ownership, is perhaps the most impartial and Mr. Bemis perhaps the most likely to be carried away by his zeal for his own side of the case. Professor Parsons throws himself into the discussion in such a whole-souled and disingenuous manner, and withal is so fertile and apt in argument and illustration, that the most bitter opponent of municipal ownership might forgive him even if he were more partisan than he is.

We cannot resist the temptation to give some illustrations of Professor Parsons' illustrations and arguments:

Our street cars [he says in answer to the claims for private railway operation in the United States] run faster, carry more strap passengers and kill and injure more people than the street cars, public or private, in any other country.

But in a foot note he claims that the private street railways of New York, Chicago, Boston and Philadelphia do not come so near to meeting the needs of the people of those cities as do the public street railways of Glasgow, Manchester, Liverpool and Dublin, the needs of the people whom they serve. In answer to the oft-repeated comparisons of street railway mileages per 1,000 population in Great Britain and the United States, to the apparent great disadvantage of the former, Professor Parsons cites as the fair basis of comparison the relative track mileages per unit of area. Thus: Although Cleveland has one mile of track to each 2,100 inhabitants against one mile to 6,400 people in Glasgow, each city has 8.4 miles of track per 1,000 acres of city area.

As to the writers in the anti-municipal ownership group under consideration, Messrs. Walton Clark and Edgar, since they write jointly, must be compared with Mr. W. J. Clark. This is perhaps unfair to the latter, since besides standing alone he closes the volume with a brief paper on British tramways. That paper, whatever the mitigating circumstances may have been, seems to be the weakest in the volume, and if it is not as partisan as the one by his associates it is largely because the subject is not so well handled. For the most part, it consists of comparisons of bulk figures, American and British, with disregard of variations in local conditions. It must be said for the paper, however, that it contains the richest gem, of its kind, in the whole three volumes. This is the glorying assertion that the damages for street railway accidents in the State of New York exceed those of the whole of the United Kingdom.

Messrs. Walton, Clark and Edgar rarely fail to strike right from the shoulder, but while in doing so they score many a point that should be given serious thought by the friends of municipial ownership, their very earnestness often leaves them exposed to counter attack—and, to change the simile, bared to the shafts of ridicule. For instance, in the course of a somewhat impassioned argument (p. 309) for democratic government and the rule of the majority, to which they claim municipal ownership is inimical, they talk of "clashes between the government and the people" and "friction between government and governed," as though a government set up by the people was somehow independent of and in conflict with them. Again: Mr. Maltbie, in answer to one of the set questions, had replied that the citizens of the British municipalities investigated were not generally interested in the management of their municipal gas works, because there are now few matters of general interest before the department.

This prompts Messrs. Clark and Edgar to say:

The lack of interest in municipal plants indicates a general indifference on the part of the public to a condition that they tolerate because they know not how to remedy.

One might have supposed, instead, that this indicated a satisfaction with the municipal plants.

The gingerly manner in which Messrs. Clark and Edgar refer to Professor Rowe's "suggestions of improper conduct on the part of the city officials" of Philadelphia in the old days of municipal ownership of the gas works is amusing. They disclaim "knowledge that enables us [them] to endorse the statements." But Mr. Clark, in the paper by him previously mentioned, evinced no lack of knowledge of other questionable phases of the earlier Philadelphia situation.

We wish we might quote entire the last two or three pages of the discussion by Messrs. Clark and Edgar, both for the sake of the warnings deserving serious attention which they contain and as further amusing examples of the lengths or heights to which "individualists," as they glory in calling themselves, are sometimes carried by their zeal for humanity and country—especially individualists who happen to be deeply interested in gas, electric light and street railway companies. We give space to the following:

We assert that the opponents of municipal ownership and operation, firm and consistent supporters of justice, are the class seeking the public welfare [*sic*] intelligently and in accordance with American principles. On this point we do not yield to any body of men. We seek, as a first principle, to insure to every man his own. . . . Our duty is to conserve the human agencies that have made our country what it is—the adventurous individual [*sic*] and voluntary association—but not to let them be our masters. This is the confession of faith of the anti-municipalizer—the anti-socialist.

With the words just quoted, Messrs. Clark and Edgar close their report, but we cannot have done with it until we have turned for a moment from their more general discussions to their treatment of some of the specific engineering questions involved in determining the financial results of municipal ownership and to the unjust inferences that the uninformed might draw from their references to engineers connected with municipal plants in the United States. This notice is already so lengthy that these further references must be brief. The accountants showed an apparent profit of $1,801,570 for the operation of the Chicago water-works in 1905. This was after bringing the municipal bookkeeping into line with the scheme set forth in the schedules formulated by or for the main committee. Messrs. Clark and Edgar turn the handsome surplus just named into an almost equal deficit, largely through the aid of Mr. Maury's belief already mentioned that 80 to 90% of the cost of the Chicago Drainage Canal and intercepting

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sewers should properly be charged to preserving the purity of the city water supply. Without going into details here, we assert that in view of the navigation and water power features of the canal, and the fact that every city must dispose of its sewage somehow, regardless of water supply, that it is unfair for Messrs. Clark and Edgar to charge against the water-works 4% interest on $45,000,000 (80%) of the outlay mentioned. In addition, these gentlemen charged against the water-works profits 4% on the appraised value of the water-works; taxes on the drainage canal, and also depreciation and operating costs on the canal.

The same general procedure was followed for the Cleveland water-works. Not being able or not thinking it worth while to dispose in like manner of the profit shown for the Syracuse water-works these "individualists" pointed out how favorable to low expenses were the local conditions at Syracuse and that certain of the water rates there were higher than similar ones charged by the private companies investigated. Water-works are thus dismissed:

If American water-works experience is to justify municipal ownership of the water supply, it must be the experiences of undertakings not investigated by this commission.

Our "individualists," in proof of the superiority of private ownership, had a search made of the files of a number of gas and electric journals and the proceedings of gas and electric societies for five years past. They found no contribution from any employee of a municipal gas plant, and only two from an employee of a municipal electric lighting plant. The two were from the same man and not on a technical subject. The American Institute of Electric Engineers, they state, included in its membership only one employee of a municipal plant and the American Gas Light Association only five. Why, it seems fair to ask, was not a like search made of the Journal of the New England Water-Works Association, the Proceedings of the American Water-Works Association, the membership lists of each organization, and the files of the civil engineering journals and societies to see what they would disclose about the activities of engineers connected with municipal water-works?

The municipal electric-works man cited by Messrs. Edgar and Clark as having written but two papers, neither of which was "technical in its nature," was Mr. Winchester, one of the members of the main committee and also one of the field experts. Of Mr. Bemis, another one of their associates, Messrs. Edgar and Clark say, in the same general connection:

The man best known among all in charge of the municipal plants that we have examined in this country is occupying an engineering position with the education and training of a teacher of political economy.

We cannot resist the temptation to quote Messrs. Edgar and Clark's modest characterization of themselves, at the very opening.

Fortunately there were on the Investigation Committee men of wide experience in the financing, construction and operation of gas, electric light and power, and street railway plants, and these men have brought from the investigation to the work of analysis important facts and impressions that would not have enriched the record of the Commission, if the National Civic Federation had not had the wisdom to include in its call possessors of expert knowledge and operating experience.

In conclusion, we are frank to say that we have laid more stress on the partisan character of the anti-municipal ownership discussions than on those in support of municipal ownership. This is partly because the former seemed to lend themselves more readily to illustrations of how very partisan most of the discussion on each side is and partly because we think that of the two the anti-municipal side is the worst sinner.

STATISTICS, CITY OF CHICAGO.—16th Quarterly-Yearly Report, February, 1908. Vol. VII., No. 4. Collected and Tabulated by the Bureau of Statistics and Municipal Library. Chicago, Ill.: Pub. Doc. Paper; 9¼ × 11¾ ins.; pp. 41 + xii.

Statistics of various phases of the activities of the city during 1907 are given by months in this quarterly bulletin, and in addition there are given the names of the leading city officials, the valuation, bonded indebtedness, taxation rates, population by wards, and a variety of departmental statistics, the latter relating to paving, water-works, sewerage, etc.

Pumping Engines.

Reviewed by NICHOLAS S. HILL, Jr.*

PUMPING ENGINES FOR WATER-WORKS.—By Charles Arthur Hague, M. Am. Soc. C. E., M. Am. Soc. M. E. New York: McGraw Publishing Co. Cloth; 6 × 9¼ ins.; pp. 372; 113 illustrations, partly in the text. $5.

The reviewer has been much interested in Mr. Hague's work upon "Pumping Engines." The volume is a welcome addition to a subject upon which too little has been written by those competent to do so, and as those directly in charge of water-works are frequently civil, rather than mechanical, engineers, pumping stations give evidence of the deficiency in knowledge of steam power-plant practice which is to be expected from the training of a civil engineer.

The author states that his book is "intended mostly for owners of water-works plants, for water commissioners, city engineers, consulting engineers, and for the men in the office, in the engine room, and in the boiler room, who are responsible for the economy and efficiency of the plant." He has probably endeavored to cater to the needs of too many classes. He refers to the use of "mathematical explanations" as causing aversion to the pursuit of technical knowledge in the minds of many. In this respect the volume under discussion is not culpable. In fact, the reviewer believes that, had simple mathematical expressions been used in parts of the theoretical discussion in which the author indulges at the beginning of his work, the information which he desires to convey could be derived with less mental effort on the part of the lay reader than by the painful perusal of long and tortuous explanations.

In fact, the author, by omitting definitions and simple formulas, lands his non-professional reader, without preparation, in the midst of the theory of the steam-engine and steam-engine design, in the first few pages of his book. It is the reviewer's belief that the first three or four chapters could be modified materially, or even omitted, without detriment to the work.

In all parts of the volume relating to theory the text is confusing, redundant, and, in many instances, ungrammatical. A few illustrations may be pertinent:

That is to say, when the temperature of a gas does not change from a higher to a lower degree, or the reverse, if the volume or cubic contents is reduced to one-half of what it was formerly, its pressure will be doubled.

It is a case of a balancing of errors, and gives the advantage of showing what may be done by what might be called a reflected light.

The initial force is easily calculated from the fact that many experiments for the determination of how much centrifugal force amounts to, has demonstrated, etc.

The author speaks of the "best general fitness of things," and, of steam in the cylinder after cut-off "as beyond reach and having to go its way for better or for worse."

The construction of the text in the entire work would be immensely improved by elimination, revision and careful proof-reading. The illustrations, too, are disappointing.

The author's theories in regard to pumping-engine design should, in some instances, be regarded as the exposition of personal opinion, although, in general, his attitude is safe, conservative and conventional.

The text is more controversial than descriptive in some places, which detracts from rather than adds to the usefulness of a reference book. A work of this kind can hardly be considered the proper channel through which to exploit one's pet theories. On the other hand, when the theoretical discussion is terminated, the author looms up large, and the relief which the reader experiences when he gets to the practical and descriptive portions of the book is pronounced. The various tables which the author publishes are worth far more than the cost of the book, and the practical hints and suggestions with which the succeeding pages abound are valuable.

The chapter on the investment value of pumping-engines is well conceived and, the reviewer believes, presents a fair and reasonable basis upon which to determine the most economical type of engine to select for a given service. The author's method of reaching his conclusions in regard to the proper mixture of concrete for engine beds is crude, may be questioned and may require needless expense, but he is on the safe side. The chapter on the conditions to which a particular type of pumping-engine is adapted affords an interesting discussion of the type of engine best suited to a specific service, and if followed will ameliorate many difficulties in the future.

In closing, the reviewer wishes to temper his criticism by an expression of appreciation of the value of the book as a whole. The book is worth criticising and well worth improving in a subsequent edition.

*100 William St., New York City.

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TECHNIK UND WIRTSCHAFT.—Monthly Publication of the Vereins Deutscher Ingenieure. Edited and Published by Dr. Hermann Beck and D. Meyer. Vol. I., No. 1, January, 1908. Paper; 6 × 9 ins.; pp. 32; illustrated. 8 marks per year.

A new departure was decided upon by the Verein Deutscher Ingenieure last summer, as reported in our columns at the time. This is the publication of a journal of engineering economics and administration, in addition to the regular journal of the society, the well-known "Zeitschrift des Vereins Deutscher Ingenieure." The new journal, which is a monthly, appeared for the first time in January, 1908, as a supplement to one of the regular issues of the "Zeitschrift," under the title "Technik und Wirtschaft," the latter word being used in its meaning of "economics" and not in its more popular sense. This interesting novelty in technical journalism is edited by Hermann Beck and D. Meyer. Its scope can not be foretold from the contents of the first two issues (the February issue having since come to hand), but apparently questions relating to the commercial and legal relations of engineering industry will form the main subjects of discussion. The journal is sold separate from the "Zeitschrift."

Methods and Devices for Bacterial Treatment of Sewage

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A History of the Steam Engine.

Reviewed by LIONEL S. MARKS.*

DIE ENTWICKLUNG DER DAMPFMASCHINE.—A History of the Stationary Steam Engine, the Locomotive, the Marine Engine and the Locomotive. Prepared at the Direction of the Verein Deutscher Ingenieure, by Conrad Matschoss. In two volumes. Berlin, Germany: Julius Springer. Cloth; 7½ × 10½ ins. Vol. I.: pp. 834; 780 illustrations in the text and 32 portraits. Vol. II.: pp. 732; 1,073 illustrations in the text and 6 portraits. 24 marks; American price, $9.60.

For the past fifteen years the Association of German Engineers has endeavored, by offering prizes and in other ways, to persuade some competent person to write a comprehensive history of the development of the steam engine. Failing to accomplish its purpose and realizing that as the years went by the records of earlier practice (such as machines, drawings and documents) were disappearing, and that the older engineers from whom information might be obtained were dying, the association finally decided to commission Herr Conrad Matschoss (whose shorter history of the steam engine had amply demonstrated his competence to undertake this more important work) to collect the material and write the book, the expenses being defrayed by the association.

The monumental work before us (two quarto volumes containing nearly 1,600 pages and about 1,800 illustrations), representing five years of arduous labor by the author, is the very satisfactory result of this enterprise. It is a work of lasting merit, a permanent work—the history of the steam engine during the first century of its extended use, has been written so comprehensively that any other work of similar scope must prove unnecessary. Other books may fill in the details and may give a somewhat different balance to the whole, by giving different weights to the engineering achievements of the different countries, but it is not easy to imagine so substantial an improvement over this book as to justify the appearance of any other work covering the same field in as comprehensive a manner. It covers its field as thoroughly—though, of course, not so delightfully—as Robert Stuart in his Anecdotes of the Steam Engine covered the history of the steam engine down to 1829.

The first section of the book is devoted to a consideration of the sources of power before the introduction of the steam engine, and the effects of its introduction on the various industries, such as mining, manufacturing, agriculture, land and sea transportation, and on the general material welfare and the cultural state of the masses of the people. Then follows a history of the introduction and the growth of the steam engine and of steam engine construction in each of the principal countries of the world, including in each case short biographies (often with portraits) of those engineers whose inventions or constructions have been of greatest importance in the development of the steam engine, and also short histories of the principal steam engine works. Thus, in the sections dealing with the United States, there are biographies of Oliver Evans, Fulton, John and Robert Stevens, Babcock, William Cramp, Allen, Baldwin, Corliss, Edwin Reynolds, and others, as well as some accounts of the Baldwin, Cramp, Corliss and other works. Statistics as to the growth of the various industries and the steam engine horse-power used in them are given for many of the countries.

The second section deals with the technical development of the steam engine, and is divided into three main parts. These are devoted, respectively, to (1) the earlier history of the steam engine, the first great steps which made it a practical prime mover, a period which closed about 1800, when James Watt had made his giant strides; (2) the development from 1800 to 1860, a period of the spreading of the steam engine, of new applications, of improved materials, workshop processes and workmanship, and (3) the development from 1860 to the present day, a period which has been marked by great improvement in the economy of steam engines, starting with the Corliss engine and the use of multi-cylinder expansion, and ending with the use of highly superheated steam; a period also in which scientific investigation of the steam engine has been carried out and utilized for the improvement of the efficiency of the engine.

It is difficult in small compass to do full justice to the completeness with which the development of the engines for various purposes, and the development of special parts of such engines, are gone into. The illustrations, both photographs and drawings, are particularly good, and are generally scaled. The reviewer has not been able to find any omission of importance, but finds much valuable material which he believes has not been published hitherto. Not only are the constructive details and developments gone into, but also the efficiencies of most of the machines described are given as determined by tests. Rotary engines, steam turbines, binary vapor engines, and other attempts at increasing thermodynamic efficiencies are treated of as fully as their importance warrants. Pumping engines, hoisting engines, blowing engines, rolling-mill engines, steam hammers, marine engines, locomotive engines, steam automobile engines, all the various types, are taken up in turn. The book ends with a review of the development of the subjects of mechanics, strength of materials, and thermodynamics during the past century.

The author and the Association of German Engineers are to be greatly congratulated on having completed this fine work. Engineers should be glad to know that they propose taking up in a similar way the history of the development of other branches of engineering, in case the present volumes meet with a satisfactory reception.

*Assistant Professor of Mechanical Engineering, Harvard University, Cambridge, Mass.

A New Edition of a Standard British Book On Roads and Pavements.

ROAD MAKING AND MAINTENANCE.—A Practical Treatise for Engineers, Surveyors, and Others. With an Historical Sketch of Ancient and Modern Practice. By Thomas Aitken, M. Inst. C. E., Surveyor to the County Council of Fife, Cupar Division. Second Edition. London, England: Charles Griffin & Co. Cloth; 6 × 9¼ ins.; pp. 525; 167 illustrations, partly in the text. 21s., net; American price, $8.40.

The first edition of this book was noted and commended in a review which appeared in Engineering News for July 25, 1901. Further reference and commendation were given in connection with a general review of the literature of roads and pavements, which was included with a notice of Baker's "Treatise on Roads and Pavements" published in our issue of Feb. 19, 1903. The present edition has been extended by 87 pages, notwithstanding the omission of obsolete matter. The greater part of the volume relates to the construction of macadam and like roads, but the various kinds of city pavements are also considered. The chapter on quarrying is extended and valuable.

In discussing "tar macadamizing," and again in the chapter on "The Prevention of Dust," the author describes and illustrates his own pneumatic tar-spraying machine. It may be noted here that in our issue of Aug. 22, 1907, we published an abstract of an article by Mr. Aitken on "The Application of Tar to Macadamized Roads."

Quite in line with the conservatism of British engineers as regards reinforced concrete, the author makes no mention of this as a material for the construction of road culverts, although he describes the use of concrete for the purpose. Elsewhere in the book there is brief incidental reference, in the chapter on subways for pipes and wires, to "ferro-concrete construction."

In an appendix of 50 pages the author reprints a report on "The Resistance of Road Vehicles to Traction," made to the British Association for the Advancement of Science by a committee consisting of Sir Alexander Binnie, Chairman; Prof. H. S. Hele-Shaw, Secretary; Mr. T. Aitken (the present author); Mr. T. C. Aveling, Sir J. I. Thornycroft, and others. This report reviews the subject indicated "from the earliest times of which records are available," which appears to be 1816. References are made to the studies of Messrs. Corréze and Manès (1832), Coriolis (1835), Morin (1837-42), Dupuit, Edmund Leahy (1847), and others of later date. Among the later authors whose writings are summarized are Prof. W. C. Unwin and Prof. I. O. Baker. The experiments of Professor Hele-Shaw are also cited. It may be added that the whole of the report given in this appendix was "drawn up" by Professor Shaw, assisted by Mr. J. F. Gill. The illustrations in this appendix include a number of half-tone views of motor vehicles of various types, with dynamometers attached, and also half-tone views of the recording instrument used.

The volume as a whole might serve in many respects as a model for a technical book, the typography being clear and generally satisfactory, even though the type is only of medium size. Possibly a few of the illustrations might have been reproduced to go on either small or folding plates, or else in the text; but there is very little to complain of in this respect. A considerable number of interesting half-tones are included, in addition to those already named.

A notable feature of the work is its cost data. These, of course, are of far less use in this country than in England, owing both to variations in local conditions and to the fact that the figures are given in pounds, shillings and pence; but, nevertheless, the figures are often suggestive. The book should find a place in every engineering library which makes any pretense of including the best works on roads and pavements.

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A HISTORY OF ASTRONOMY.—By Walter W. Bryant, B. A., Superintendent of the Magnetical and Meteorological Department of the Royal Observatory, Greenwich. New York: E. P. Dutton & Co. Cloth; 5½ × 9 ins.; pp. 355; 35 plates. $3, net.

The history of any science forms a story of absorbing interest. To the mind with scientific tendencies, perhaps to most men of every walk of life, it is a story incomparably more fascinating than any history of political events, eve nof the most stirring period in the life of an active race or nation. So much the more then, must the history of astronomy, the science of transcendental exploration and measurement, possess a powerful charm. However, astronomy suffers more often than any other field of knowledge, from the blight of "popular" writing, which spreads sensationalized portrayals of ultimate achievements before readers too careless to cast even an occasional glance at the everyday procession of the constellations. In Bryant's "History of Astronomy" the narrative of progress and discovery is kept clear of this vulgarizing influence; the terseness and sanity of scientific statement characterizes the work. The book, therefore, has qualities which all readers will appreciate; it is amply worth buying, reading and keeping.

There is a special interest to the engineer in the history of astronomy. During the beginnings of the science, both in the period of antiquity and in the period of Copernicus and Galileo, when the foundations of the modern knowledge were laid, geodesy, was vitally connected with astronomy. Little more than astrology existed until the belief in the spherical shape of the earth gained ground; and the earliest geodetic achievement, Eratosthenes' measurement of an arc of the meridian, no doubt did much to make possible the remarkable astronomic progress of Greece and Alexandria. In the modern age, not only did the evolution of our knowledge of the solar system depend upon measurement of the actual size of the earth, but several generations of the most important astronomical development were directly stimulated by the demands of navigators for a method of determining longitude, an essentially geodetic problem. To the engineer, therefore, the history of astronomy is the history of a science very closely affiliated to fundamental technical operations.

Journalistic Hero Worship.

THOMAS ALVA EDISON.—Sixty Years of an Inventor's Life. By Francis Arthur Jones. New York: Thomas Y. Crowell & Co. Cloth; 5¼ × 8⅛ ins.; pp. 362; 29 plates. $2, net.

The author of this book has tried to deal with technical inventions without, apparently, any very definite idea of what many of the terms used really mean. To an engineer the weakness of this book is apparent. The true life story of a great inventor like Edison must be interwoven with truly technical discussions and should not have been exhibited as it here is, without the collaboration of some one who understands the nature of the phenomena and the actions on the materials involved. The moment Mr. Jones leaves the man to write of his inventions many of his own ideas seem hazy and his expressions become doubly vague. It may be argued that this book is a popular biography and therefore should not contain technicalities. But technical matters cannot be clearly dealt with in a non-technical way unless they are clearly understood by the author.

The book opens with a description of life in Milan, Ohio, in 1847, before Edison's birth. In true newspaper style the author narrates that event with the vividness of an eye witness. One passage is worth quoting, as showing the spirit of the work:

> Presently the nurse who had been looking after Mrs. Edison—a good-hearted neighbor—entered the room and informed Mr. Edison that he was the father of a fine, sturdy boy. "A pretty child," said the nurse, "fair, with gray eyes—the very image of his mother." Mr. Edison received the news philosophically, and a little while later, when allowed to see the child, he regarded it with great interest.

The familiar story of Edison's early life, of his days as a newsboy and a youthful editor, as a telegrapher, are retold with some new embellishments. In describing his famous inventions, the stock ticker, the incandescent lamp (called here "the electric light"), the phonograph, the kinetoscope, the nickel-iron storage battery and other inventions, the author throws many side lights on the development work and gives a fund of anecdote, but not much of value concerning the inventions themselves. The paragraphs on "Banquets," "Anecdotes," "Opinions," etc., form the interesting part of the book. There are reproductions of many interesting photographs of the inventor which, the author states, were made for this book with many helpful suggestions from Mr. Edison. There seems to be some ground to believe that the inventor gave Mr. Jones every opportunity to prepare a volume containing some new and interesting matter; even allowing him to ransack his library, to rummage his laboratory and to study his home. If so it is all the more regrettable that the many interesting passages should be so promiscuously peppered with inaccurate and misleading technical matter.

HANDBUCH FUER EISENBETONBAU.—Edited by F. von Emperger. Vol. II.: The Material and Its Manipulation. Prepared by K. Memmler, H. Burchartz, H. Albrecht, R. Janesch, O. Rappold, A. Nowak. Berlin, Germany: Wilhelm Ernst & Sohn. Paper; 7¼ × 10½ ins.; pp. 243; 420 text illustrations and 1 folding plate. 12 marks; American price, $4.80.

The three-volume treatise on reinforced concrete which is appearing under the editorship of Mr. F. von Emperger, is distinguished by the curious order of publication. The third volume was the first to appear (in two parts, reviewed in the Engineering Literature Supplement of May 16 and Aug. 15, 1907). The second volume now follows, and presumably the work will soon be completed by the issue of the first volume. The second volume should prove the most widely useful of the three, because of the large number of sketches and views of form-work and centering which it contains. Just half the book, 121 pages, is devoted to forms and centers, and the larger part of this space is occupied by illustrations; the accompanying text is a description of the constructions shown. The contents of the first half of the volume comprises a discussion of the materials of reinforced concrete and their handling, including testing, transportation and placing in the forms, and a 20-page description of European concrete mixers.

The names of the authors guarantee the excellence of the text, a guarantee supported by an inspection of the book. The illustrations fall short of the clearness and neatness found in some other German publications, but on the whole are amply sufficient for their purpose.

ENGINEERING WORKSHOP PRACTICE.—By Charles C. Allen, Lecturer in Engineering, Municipal Technical Institute, Coventry. New York: E. P. Dutton & Co. Cloth; 4¾ × 8⅛ ins.; pp. 254; 152 illustrations in the text. $1.25, net.

The title of this book does not truly indicate the character of its contents—to Americans at least. The subject-matter is metal working or machine-shop practice alone; woodworking, forging or foundry work have no part.

The first 30 odd pages are given up to a general discussion of materials and kinematics, as involved in machine-shop practice. This section is doubtless intended more for what the author terms "engineering workmen" than for those students who may have recourse to his book. The vagueness of some parts of this section might well be replaced by more exact statements. About 20 pages hold descriptions of gages, micrometer and vernier callipers, and their proper field and use. The following 18 pages treat of tool steels and their manipulation, and the next few pages contain practical directions for brazing, soldering, riveting, etc. The rest of the book is mainly composed of chapters on chipping, filing and scraping, on lathe work, boring, planing, milling, grinding, screw cutting, gear cutting, etc. It should be remembered that English practices are outlined and not American. At the end, the author gives schedules of work for first-year and second-year courses. These are little more than skeletons, and a student working without an instructor would be at a loss to know how to employ the processes named. If the exercises are for beginners in metal working, the instructions are not definite enough, and if the students are already familiar with the tools and machinery then the exercises are too elementary. The volume as a whole may be indicative of British instruction in metal working, but it cannot be taken as representative of American methods and could not well serve as a guide in manual-training schools and technical-school workshops on this side of the Atlantic.

WHITTAKER'S ARITHMETIC OF ELECTRICAL ENGINEERING.—For Technical Students and Engineers. Containing 72 Worked Examples and 300 Exercises. London, England: Whittaker & Co. (New York: The Macmillan Co.) Cloth; 5 × 7½ ins.; pp. 159; 13 figures in the text. 50 cts.

This small volume contains between 300 and 400 exercises and examples of the applications of the fundamental laws and elementary principles of electrical engineering. These exercises are of the class that some American authors of text-books often place at the end of the various chapters. The book might well form the base of exercises to be worked outside of class rooms to help fix the elements of the subject in the student's mind. The exercises are all practical and portray actual cases. The book is divided into 14 chapters, each of which treats some particular division, such as "conductors and resistance," "work and power," "divided circuits," "electro-chemistry," "magnetic quantities." Each chapter opens with definitions and brief statements of the law, principle or formula under consideration. Then follow a few worked examples, showing the methods of attacking problems. The chapters close with 20 to 30 unworked exercises on lines similar to the worked examples.

THE PRESENT AND FUTURE OF THE BITUMINOUS COAL TRADE.—A Report to The Bituminous Coal Trade Association. New York: The Association (Henry S. Fleming, Secretary, 1 Broadway). Boards; 6½ × 10¼ ins.; pp. 87; folding and other plates, and folding diagrams in pocket.

This report deals with the bituminous coal production, consumption and resources of the world, and is necessarily statistical to a great extent. Past and future production and consumption in the various coal districts of the United States are principally studied. The method of judging future production is based on a determination of the theoretical curve of the tonnage of past years. The knowledge of coal-field deve[lop]ments in all parts of the world is summarized [in] a section on the resources of the world. Th[e] figures representing present coal consumption [are] now so large that their direct comparison [con]veys little meaning and numerous curves and [dia]grams accompany the report to illustrate the [pro]duction movement.

HOW TO READ PLANS.—A Simple Practical [Ex]planation of the Meaning of the Various Lin[es], Marks, Symbols and Devices Used on Working D[raw]ings so That They Can Be Correctly Followed by [the] Workman. By Charles G. Peker, Editor "W[ood]worker Review," Co-Author of "Easy Lessons in [Me]chanical Drawing," etc. New York: Industrial [Pu]blication Co. Cloth; 4¾ × 7½ ins.; pp. 46; 43 illus[tra]tions in the text and 8 plates. 50 cts.

Had the author added "Architectural" to his main title his sub-title would have been sufficient explanation of the scope of his book. As to the character of the volume, it need only be said that the directions are so plain and the illustrations so illustrative that any workman who cannot understand the instructions would probably not be worth employing as a workman at any price.

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Continuous Current Engineering.

Reviewed by HENRY H. NORRIS.*

AN INTRODUCTORY COURSE OF CONTINUOUS CURRENT ENGINEERING.—By Alfred Hay, D. Sc., M. Inst. C. E. New York: D. Van Nostrand Co. Cloth; 5¼ × 8¼ ins.; pp. 327; 183 illustrations in the text. $2.50, net.

The purpose of this book is to acquaint the reader, assumed to be already familiar with the elements of electricity and magnetism, with the construction of the component parts of an electrical installation. It is largely descriptive, the text being illustrated with diagrams of electrical devices and circuits.

Three chapters are taken up with the physics of continuous currents and magnetism. Numerical examples of a practical nature are used to illustrate the definitions. Following this introduction are two chapters on measuring instruments, the descriptions being largely those of English practice. The Aron, Ferranti and other electricity supply meters, which are popular abroad, but comparatively unknown here, are treated in detail and in an interesting manner. Instructions for calibrating ammeters and volt-meters are included. Several chapters are given to the dynamo, both as generator and motor. In these chapters principles, construction and operation have their due allotment of space. The several topics are discussed under well selected headings, so that it is possible to refer to a particular subject with little trouble. Such important matters as armature reaction, calculation of reactance voltage and causes and prevention of sparking are handled in a simple and logical way, without unnecessary complications. This section includes a chapter on the testing of machines, which should be sufficient to enable the reader to perform the ordinary tests without great difficulty. That the book is up-to-date is indicated by the inclusion of the description of the recently developed Rosenburg constant current dynamo, and of a modern 400-KW. turbo-generator. The remaining third of the volume is taken up with a somewhat miscellaneous but entirely satisfactory treatment of secondary cells and their manipulation, electric lamps and electric lighting, switches and electrical conductors.

The book would be improved by the introduction of chapter headings which could be easily selected, as the chapters are well arranged and practically self-contained.

In order to locate the book in the field of electrical literature, it may be compared with "The Elements of Electrical Engineering," by Franklin and Esty.† It is a smaller book than the latter, is more descriptive in character, and is better illustrated. The topics treated, the order followed and the general plan and purpose of the two works are very similar. On the whole, Mr. Hay's book would probably be more useful to the beginner. At the same time, the fact should be emphasized that a practical familiarity with electrical machines is necessary in order to enable the reader to obtain the full benefit from this or any other book. Electrical engineering cannot be learned from books, the function of which is to point out the reasons for present practice, and to systematically lay down the principles involved. For a reader with this preparation Mr. Hay's book will prove easy and instructive reading. It may be added that it is similar in size and style to "Alternating Currents,"‡ by the same author. It is much simpler in method than the latter and should form a good introduction to it.

It is interesting to note that authors of electrical books are at the present time giving considerable attention to the elements of the subject. This indicates that there is a need for books which can be read profitably by beginners and by engineers not specialized in electrical work. If it is possible to produce books which, with a reasonable degree of practical experience on the part of the reader, will enable him to grasp the fundamental underlying physical and engineering principles, they will be greatly appreciated. Mr. Hay's book is a promising attempt in this direction.

*Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.

†Reviewed in this Supplement, Oct. 18, 1906, p. 417.

‡Reviewed in this Supplement, April 12, 1906, p. 430.

MASSEN-DESTILLATION VON WASSER.—With Special Reference to the Supply of Drinking Water and Locomotive Feed-Water. By Ludwig Bothas. Berlin, Germany: Julius Springer. Paper; 5½ × 8½ ins.; pp. 53; illustrated. 2 marks. American price, 80 cts.

Water-supply conditions in some sections of Russia are so bad that reasonably satisfactory water can be obtained only by long-distance haul or else by distilling local water. In most such cases the result is what might be expected, namely that the bad local water is used without attempt at improvement. However, considerable advance has been made in improving bad water by distillation. A half dozen distilling plants for furnishing locomotive feed-water and a similar number of plants for supplying potable water have been built. A pressure system of multiple-effect distillers, devised by a Russian engineer, N. F. Jagn, seems to have been most largely used. The above-mentioned pamphlet devotes itself to a description of this system and comparison with the so-called "English" or pressure-vacuum system. It appears that the largest plant of the kind is one built in 1897-8, for the city of Baku, 200,000 inhabitants. This plant has a rated capacity of 245,000 gals. per day, or a maximum of 300,000 to 350,000 gals. It is further noteworthy for the provision for removal of copper and iron from the distillate; the former is introduced by solution from the copper of the plate condensers, and is removed by passing the water through tanks filled with iron turnings, while this latter process itself necessitates removal of iron by aeration and filtration. The water is distributed through pipes, where it again takes up much iron, but only a small part of the population uses it, as may be seen from the fact that the production is only 1 gal. per capita per day.

CONTRACTS AND SPECIFICATIONS.—A Working Manual of Correct Forms Covering the Relations of Architect, Contractor and Owner, Methods of Awarding and Executing Public and Private Contracts, and Instruction in the Art of Specification Writing. Part I., by James C. Plant, Superintendent of Computing Division, Office of Supervising Architect, U. S. Treasury Department, Washington, D. C. Part II., Edited by Alfred E. Zapf, Secretary, American School of Correspondence, Chicago, Ill. Chicago, Ill.: American School of Correspondence. Cloth; 6½ × 9¾ ins.; pp. 112; plates and text illustrations. $1.

Aside from a few scattered general rules this book is not a treatise on "Contracts and Specifications," but rather a short and not altogether useful compilation of the more important details of a specification for a small dwelling house [forming a part of the Cyclopedia of Architecture, etc., noticed in our issue of Dec. 12, 1907]. In addition to the limited field covered, the arrangement of matter is so bad that very necessary information is concealed among glittering platitudes, fairly safe from the inquisitive eye. The two parts cover the same ground and the very frequent contradictions are glossed over by the following time and labor saving evasion:

> Because some things are stated differently in one part from the other, is no reason for considering either line wrong. No one set of rules will apply to all cases; and therefore the differences between the two parts . . . will lead the student to compare in each case the two lines, and choose the one best adapted to the case he may have in mind, or else go on and work out some third or independent line which will better than either fit the case. The man who thinks and reasons, provided he is well grounded in fundamentals, will rarely make a mistake.

THE WEATHERING OF COAL.—By S. W. Parr and N. D. Hamilton. Bulletin No. 17, University of Illinois Engineering Experiment Station. Urbana, Ill.: The University. Paper; 6 × 9 ins.; pp. 37; 10 illustrations in the text.

This bulletin contains two papers, one on "The Weathering of Coal" and the other on "The Deterioration of Coal Samples" in the laboratory. The first paper outlines the extent to which coal is being stored in the open, reviews the very meager literature on weathering of coal and presents a summation of the opinions of prominent engineers and scientists. The experimental work is described as it was carried on with 100-lb. samples for nine months under (1) outdoor exposure, (2) exposure to dry atmosphere of 85° to 120° F., (3) drenched with water two or three times per week, (4) submerged in water at 70° F. The results briefly and in general showed that submerged coal does not appreciably lose in heat value, that outdoor exposure results in 2% to 10% depreciation, that dry storage seems to have no advantage except with coals of high sulphur content, that losses in storage seem to be complete in five months.

The second paper relates the history of certain discrepancies in heat analyses made by the United States and the Illinois State Geological Surveys. In endeavoring to ascertain the causes of these persistent differences it was found that samples of coal sealed in glass jars in the laboratory underwent certain changes so that their heating values were appreciably lowered. The general conclusions of the studies of this phenomenon, as presented in this bulletin, are that combustible gases exude from the coal from the very time of breaking out of the vein, that there is an accompanying absorption of oxygen, that samples in the most carefully sealed laboratory containers are subject to deterioration, and that the rapidity of these changes greatly varies with different coals and is most evident during the first two or three weeks after taking the sample from the vein.

KALENDER FUER DAS GAS- UND WASSERFACH.—By E. Schilling, Civil Engineer. Section on Water by G. Anklam, Manager of the Berlin Water-Works at Friedrichshagen. 31st Year, 1908. Munich and Berlin, Germany: R. Oldenbourg. Leather; 4 × 6½ ins.; pp. 284 + 139; 16 illustrations in the text. 4½ marks; American price, $1.80.

The 260 pp. of this yearbook in which information on gas production and water supply is collected are very unequally distributed, about three-fourths being devoted to gas and only 70 pp. to water. The latter section, in consequence, is totally inadequate to represent its subject, even making every possible allowance. The section dealing with gas is considerably more complete, but appears to be by no means exhaustive. The second half of the volume contains, besides diary and memorandum pages, etc., a valuable list of gas and water-works and their chief officials in the cities of Germany, Austro-Hungary and the chief cities of Europe outside of these countries.

ROAD PAMPHLETS.—Wisconsin Geological and Natural History Survey, E. A. Birge, Ph. D., Sc. D., Director. By Arthur R. Hirst, B. S., Highway Engineer. Madison, Wis.: Pub. Doc. Paper; 4¾ × 7 ins.

No. 1: Earth Roads. Pp. 32; 13 text illustrations.
No. 2: The Earth Road Drag. Pp. 24; 4 text illustrations.
No. 3: Stone and Gravel Roads. Pp. 32; 12 text illustrations.
No. 4: Culverts and Bridges. Pp. 54; 15 text illustrations.

The printing press is being brought into requisition as never before to aid the good roads movement throughout the United States. The pamphlets noted above are popular expositions of the subjects indicated, and should be useful for their intended purpose.

Switches and Turnouts
By HOWARD CHAPIN IVES
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An Excellent Manual of Forging.

THE BLACKSMITH'S GUIDE.—Valuable Instructions on Forging, Welding, Hardening, Tempering, Case-hardening, Annealing, Coloring, Brazing, and General Blacksmithing. By J. F. Sallows. Brattleboro, Vt.: The Technical Press. Cloth; 4¼ × 7¼ ins.; pp. 157; plates and text illustrations. $1.50.

There has been a long-standing complaint from shopwork instructors and some shop foremen that there was no thoroughly reliable, up-to-date book on forging, or blacksmithing, in which the elementary practice was accurately presented in compact form. This complaint now seems to have been met in large measure by this little book, which will be welcomed by all who are interested in this branch of manual training or in commercial hand-forging. The language of the book is good; the explanations are clear; the arrangement is pleasing, and no extraneous matter has been admitted. In these respects the book differs so much from those on similar subjects that one is inclined to believe that no little part of this excellence is perhaps due as much to capable editing as to careful work by the author. One criticism that has been made of such books is that they have fairly bristled with the author's disconcerting personal allusions (or illusions), from the portrait-frontispiece to the final peroration on "room at the top." The reader of Mr. Sallows' book will be relieved to find that there is neither portrait nor peroration. At times the author drops into the use of the first person singular, but in this he does not impair his descriptions.

The matter is arranged in six chapters, and an appendix, covering particularly forging machine parts and tools, hardening and tempering, manipulation of high-speed steels, case-hardening and coloring, brazing and general blacksmithing. Through the book are numerous suggestions for new methods, all of which are convenient and some of which are illuminating. The only point to which practical workers can well take exception is in Mr. Sallows' method of forging a cold chisel. He would make the length of cutting edge less than the width of the body so that the chisel cannot clear its cut if used even slightly below the surface.

The author explains and recommends an interesting method of hardening steel. The tool is heated to match in color a chosen portion of a color chart, which runs from dark red through yellow to white. The tool is then quenched in brine and in oil. If the proper heat is attained, as directed, there is no need of tempering, and the tools are in perfect condition for grinding and use.

STATE WATER-SUPPLY COMMISSION (New Jersey).—Report to the Legislature, 1908. (M. R. Sherrerd, Consulting Engineer, City Hall, Newark, N. J.) Trenton, N. J.: Pub. Doc. Paper; 5¾ × 9 ins.; pp. 27.

The greater part of this report is taken up with extracts from governors' messages, showing the need of conserving the waters of the state, etc., and with statistics on the municipal water supplies of New Jersey, from the report of this commission's predecessor, the Potable Water Supply Commission. A little space is devoted to the work done by the present commission, which thus far has been largely preliminary.

GENERAL SPECIFICATIONS FOR CONCRETE BRIDGES.—By Wilbur J. Watson, Consulting Engineer. Cleveland, Ohio: M. A. Vinson. Stiff paper; 6¾ × 9½ ins.; pp. 82; tables and illustrations. $1.

This pamphlet is prepared in similar fashion to the "General Specifications for Concrete Work," by the same author, reviewed in our issue of Feb. 20, 1908. It contains the same clauses in regard to the general principles of concrete construction, with additional notes on the more specific practice of bridge design and construction. The title seems rather a misnomer. As generally regarded, specifications are the written clauses, supplementing drawings, by which a contract between owner and builder is interpreted. They explain, always with the aid of the drawings, what the contractor is required to perform. While Mr. Watson's so-called specifications contain many of the stock phrases of specification writing, still the larger proportion of the clauses and appendices are really instructions to the engineer about to design a concrete bridge. Viewed in that light the pamphlet is admirably compiled. However these are "specifications" in the same sense as the well known "Cooper's Specifications for Highway and Railway Bridges" and should, as the author says, in the preface

be especially useful in cases where they are made the basis of competitive designs, as in that case it will be possible to compare all such designs on an equal basis.

The Elements of Railroad Engineering

RAILROAD ENGINEERING, Vol. II.

By William G. Raymond

C. E., LL.D., Professor of Civil Engineering and Dean of the College of Applied Science, the State University of Iowa

8vo, xvi + 405 pages, 107 figures, 18 plates Cloth, $3.50

CONTENTS—Introduction. Part I: Permanent Way. Alignment. Rails. Rail Fastenings. Ties. Ballast and Roadbed. Culverts, Bridges and Minor Structures. Turnouts. Side Tracks and Yards. Elevation of the Outer Rail. Signaling. Part II: The Locomotive and its Work. The Locomotive. The Weight of the Locomotive. Locomotive and Grade Problems. Railroad Expenditures. Effect on Operating Expenses of Change in the Number of Trains, the Tonnage Remaining Constant. Discussion of the Effect of Distance, Rise and Fall, and Curvature of Train-mile Costs. Problems in Change of Ruling Grade, Distance, Rise and Fall and Curvature. Part III: Railroad, Location, Construction and Betterment Surveys. Reconnoissance, Preliminary Survey. The Location Survey. Construction Surveys. Betterment Surveys. Appraisals. The Location of the Knoxville, La Follette and Jellico Railroad.

JOHN WILEY & SONS, 43 and 45 E. 19th St., New York City

PRACTICAL CALCULATIONS FOR ENGINEERS.—For the Use of Engineering Students, Apprentices, Draftsmen, Mechanics, Foremen, and Others Practically Engaged in Engineering Work. By C. E. Larard, M. Inst. M. E., etc., Head of the Mechanical Engineering Department at the Northampton Institute, London, E. C., and H. A. Golding, Assoc. M. Inst. M. E. London, England: Charles Griffin & Co., Ltd. Philadelphia, Pa.: J. B. Lippincott Co. Cloth; 5 × 7¾ ins; pp. 455; 212 illustrations, mostly in the text. $2, net.

Larard & Golding's "Practical Calculations for Engineers" is something of a novelty in technical literature. The usual study courses and textbooks have the object of giving instruction in principles, and examples of their application are a secondary matter. This book aims solely to give practice in making calculations, to help in the difficult task of converting school-taught principles and rules into working tools. Many a man is weak just at this point: Knowing the principles which govern the solution of a problem he is slow and clumsy in going through the calculations which express their application to the problem.

The case is roughly parallel to the deficient skill in writing a clear and correct style, about which there is so frequent complaint in engineering circles. There is such a thing as an easy and effective style in calculation, as in writing.

This book, it is true, is not intended primarily for engineering students, that is college students. It is for "engineering students, apprentices, draftsmen, mechanics, foremen, and others practically engaged in engineering work." Mensuration, logarithmic calculation and the use of the slide rule are subjects which the engineering college student is well familiarized with, and the three chapters devoted to these subjects will not give him much new matter. Two chapters on the use of cross-section paper, however, can prove stimulating to him, Chapter V on "The Value of Squared Paper," and Chapter XXI on "Use of Squared Paper in an Engineering Establishment." For all the other classes of readers mentioned, all these chapters will be of great value.

The main part of the book consists of eleven chapters which detail the calculations necessary in different parts of mechanical engineering work: Pulleys, Work and Power, Transmission, Centrifugal Force and Balancing, Acceleration, Steam Boiler and Engine, Costs of Power Production, etc. Necessarily, much of the space is taken up by statements of the governing principles, but this is always done with direct view to making calculations of results, and not with a view to teaching the principles themselves. Examples are figured out in the text at every stage, and a large collection of examples is given at the close of each chapter.

The book is thus aimed at those who are engaged in mechanical engineering work, whether in the shop or in the office. It can do best service to men who lack an education in engineering theory, but even many of these, technical college graduates, may find it a guide to improvement.

Three chapters at the close of the book discuss Calculation of Weights, Preparation of Estimates, and Remuneration of Labor (piecework and premium systems). The final chapter, on various uses of cross-section paper, has already been mentioned.

U. S. RECLAMATION SERVICE.—Monthly Bulletin, February, 1908. Washington, D. C.: Pub. Doc. Paper; 8 × 10½ ins.; pp. 9 to 16.

The U. S. Reclamation Service has now followed the Isthmian Canal Commission in establishing a bulletin for the dissemination of information among its employees and others interested. A large part of the February bulletin (the second one issued) is occupied by "Service orders." In addition there is a list of appointments, etc., to the Service, and a detailed statement of the personnel of the Reclamation organization.

THE WORK OF THE SECOND HAGUE CONFERENCE.—James Brown Scott. Document 5, January, 1908. Association for International Conciliation. New York: American Branch of Association (Substation 84). Paper; 5¼ × 8 ins.; pp. 27.

The results achieved by the last Peace Conference at the Hague are reviewed in this title pamphlet. In addition they are summarized as follows:

(1) It provided for a meeting of a Third Conference within an analogous period, namely eight years, to be under the control of the Powers generally, instead of the control of any one of them.
(2) It adopted a convention for the non-forcible collection of contract debts, substituting arbitration and an appeal to reason for force and an appeal to arms.
(3) It established a prize court to safeguard neutrals, and
(4) It laid the foundations of, if it did not put the finishing stone to, a great court of arbitration.

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Electrical Engineering.

Reviewed by HENRY H. NORRIS.*

A TEXT-BOOK OF ELECTRICAL ENGINEERING.—Translated from the German of Dr. Adolf Thomälen by George W. O. Howe, Assoc. M. Inst. E. E., Lecturer in Electrical Engineering at the Central Technical College, South Kensington. New York: Longmans, Green & Co. London, England: Edward Arnold. Cloth, 6 × 10 ins.; pp. 456; 454 illustrations in the text. $4.20, net.

In a recent review† of the third German edition of this work, the statement is made that it is considered abroad a standard text on the subject covered by its title, "Kruzes Lehrbuch der Elektrotechnik." The translation by Mr. Howe is from the second edition, but he has had access to the material which was added in the preparation of the third German edition. The translation will introduce the work to a still larger circle of readers and it will take its place with such books as Hay's Alternating Currents‡ and Lamb's Alternating Currents§ which in the alternating current sections it in many ways resembles. While the translation in general follows the original text the translator has felt free to introduce modifications, and he has done so in a few instances. The title of the book is too comprehensive, implying as it does that the entire field of electrical engineering has been covered. This is not the case, as one short chapter on electrolysis is the only material which does not deal directly or indirectly with generators, motors and transformers. The ambition of the author has been to enable the student to obtain such an intimate knowledge of the underlying principles that he may be able to analyze for himself the many phenomena which are the basis of electrical applications. Dr. Thomälen uses the happy phrase "electrotechnisches Denken" in expressing this idea.

Beginning with the simplest applications of the electric current, the author defines in an informal and interesting way the conceptions of current, electromotive force, resistance and other fundamental quantities. Series and parallel electric circuits are employed in stating and proving the laws of the electric circuit. A short chapter contains explanations of the laws of electrolysis, leading up naturally to the accumulator, the primary cell and the voltmeter. The chemical equations for the ordinary electrolytic reactions are given. Chapter III. takes up the physics of magnetism, and Chapter IV. that of electromagnetism. The relations between the electric and the magnetic circuit, in producing both mechanical force and electromotive force, are described and illustrated by means of formulas and numerical examples. The introductory chapters are concluded by one on the dimensional, mechanical, magnetic and electrical units. Up to this point the treatment is quite similar to that given in the standard works on physics.

Beginning with Chapter VI., and throughout the remainder of the book, engineering subjects predominate. Practice and theory are interwoven, the latter being introduced at such points as will make it effective in showing the reasons for the practice. As the illustrations used to explain both the theory and practice consist of conventional diagrams, the reader must be familiar with the appearance and general construction of generators, transformers and motors of various kinds. Chapter VI. is a rather elaborate discussion of armature windings, a number of the principal types, several which are no longer in use in this country, being described and diagrammatically illustrated. These windings are practically all for continuous current machines. A chapter on the excitation of dynamos, on field magnets, on armature reaction, on commutation, etc., begins with a description of the various means employed for producing the magnetic field in generators and motors. A number of obsolete field magnets are shown, and an estimate of the magnetic leakage in these is made. Sparkless commutation is treated rather elaborately, with mathematical analysis, the article on this subject being typical of the very thorough manner in which fundamental subjects are studied throughout the book.

After these general introductory matters have been laid before the reader the author proceeds to a careful discussion of the following topics, each of which is given a chapter, unless otherwise stated in parenthesis; dynamo characteristics; principles of motors; the alternating current circuit; transformers (2 chapters); alternators (2 chapters); alternating current motors (4 chapters), and rotary converters. Practically no descriptions are given, but the theory is worked out by means of algebra and geometry and the bearing of the theory on practice is indicated. The effort is made to force the reader to realize the physical meaning of the theory. As an illustration of this and of the style of the text, a few sentences from the section on the parallel connection of alternators are presented:

> The connection of alternators to bus-bars on which other alternators are already working is, in many respects, like the similar operation with a direct-current generator. If a shunt dynamo has to be put in parallel with other machines which are already running, it is run up to speed on open circuit, and its field current is adjusted until its E. M. F. is equal to the P. D. between the bus-bars. The switch is then closed and the terminals of the dynamo connected to the main terminals or bus-bars of the same sign.
>
> With alternators the machine is started on open circuit and run up to speed. The speed, however, must be carefully adjusted so that the frequency is that of the bus-bars. The field current is then adjusted until the E. M. F. is equal to the P. D. between the bus-bars, etc.

After introducing the subject in relation to the knowledge which the reader is assumed to have, the theory is worked out in detail.

Vector diagrams, especially "circle" diagrams, are freely used. This is illustrated in the study of the performance of the induction motor, which is exhaustively analyzed. These diagrams appear in increasing numbers toward the close of the book, while at the beginning the diagrams are very simple. It is assumed either that the book will be studied from beginning to end or that if the latter part is used for reference it will be by persons already reasonably familiar with the standard electrical circuit diagrams. A beginner, glancing at the last few chapters, will be discouraged. But if, equipped with a practical familiarity with electrical apparatus and a training in elementary mathematics, he will take up the topics in the excellent order in which they are arranged, he will experience only the ordinary difficulties met in mastering a subject inherently rather difficult.

*Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.
†See Eng. News, Nov. 14, 1907, p. 536.
‡Reviewed in this Supplement for April 12, 1906, p. 430.
§Reviewed in this Supplement for Dec. 13, 1906, p. 635.

Just Published

THE DESIGN
OF
Typical Steel Railway Bridges

An Elementary Course for Engineering Students and Draftsmen

By W. CHASE THOMSON

M. Can. Soc. C. E.
Assistant Engineer, Dominion Bridge Co., Ltd., Montreal
Author of "Bridge and Structural Design"

Cloth; 6 x 9 inches; vii + 178 pages; 21 diagrams and detail drawings (including 5 folding plates)

Price, $2.00 net

This work is a sequel to "Bridge and Structural Design," by Mr. Thomson, and, like it, has been developed from a series of lectures given by him under the auspices of the Dominion Bridge Company. The structures chosen for treatment represent the types of railway bridges most generally in use, and have been selected because they are best suited to illustrate the problems which present themselves most frequently to the bridge designer. They include the following: a 60-ft. Deck Plate Girder, a 100-ft. Deck Warren Girder, a 150-ft. Through Pratt Truss, a 200-ft. Through Pratt Truss with curved top chord, a 170-ft. Swing Bridge, and a Railway Viaduct.

The work opens with a general specification for governing the loads, unit stresses, and such other details as require the attention of designers. This is followed by tables setting forth the unit stresses permissible in columns and the rivet values used in the designs. Instructions are then given for constructing the moment diagram which is employed in computing the bending moments and shears for wheel loads. This has been found to be the most satisfactory method of dealing with wheel loads, as it affords a rapid and reliable solution, and significant errors are less likely to occur with its use than with that of any form of moment table.

The designs of the different structures are then considered in detail. Commencing with the main dimensions of the structure to be designed, and stating the loads which it has to carry, the stresses in its various members are first determined. The dimensions of these members are then computed and the details carefully worked out. The numerical calculations are given in full for each design, together with an estimate of the weight of the completed structure. This last feature is an important one, as estimating forms a large part of the work of the designer.

Some of the more important variations from the types of bridges considered are also dealt with briefly in Chapter VIII., in order to show how the principles previously set forth and illustrated may be applied to them. In the chapter devoted to the design of a 170-ft. swing bridge, the calculations for the lifting and turning machinery are given in full. The closing chapter is given up to the explanation of a simple and logical method of proportioning the lattice bars of compression members, together with its application to a number of specific instances.

The author, an experienced engineer actively engaged in bridge design, has produced a book of manifest practical value for the instruction of civil engineering students, and one which can be studied with profit by those in actual practice, as well as by draftsmen who desire to become familiar with the methods employed in designing offices.

The Engineering News Book Department
220 Broadway, New York

Publications Received.

AIRSHIPS PAST AND PRESENT.—Together with Chapters on the Use of Balloons in Connection with Meteorology, Photography and the Carrier Pigeon. By A. Hildebrandt, Captain and Instructor in the Prussion Balloon Corps. Translated by W. H. Story. New York: D. Van Nostrand Co. Cloth; 5¾ × 9½ ins.; pp. 364; 222 illustrations, mostly in the text. $3.50, net.

ANALYSIS OF MIXED PAINTS, COLOR PIGMENTS, AND VARNISHES.—By Clifford Dyer Holley, M. S., Ph. D., Professor of Industrial Chemistry, North Dakota Agricultural College, and Chemist on the Staff of the North Dakota Experiment Station, and E. F. Ladd, B. S., Professor of Chemistry, North Dakota Agricultural College, State Chemist and Food Commissioner for North Dakota. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5 × 8¼ ins.; pp. 235; 10 text illustrations and 1 plate. $2.50.

AUSTRALIAN PRODUCTION.—Bulletin No. 1. Summary of Commonwealth Production Statistics, for the Years 1901 to 1906. Published under the Authority of the Minister of Home Affairs, by G. H. Knibbs, Commonwealth Statistician. Melbourne, Australia: Commonwealth Bureau of Census and Statistics. Paper; 8¼ × 13 ins.; pp. 28.

BOARD OF HARBOR AND LAND COMMISSIONERS (Massachusetts).—Annual Report for the Year 1907. Boston, Mass.: Pub. Doc. (No. 11). Stiff paper; 5¾ × 9¼ ins.; pp. 144; folding maps (three in pocket).

BOARD OF RAILROAD COMMISSIONERS (Massachusetts.).—Annual Report, January, 1908. (Walter Perley Hall, Chairman, Fitchburg, Mass.) Boston, Mass.: Pub. Doc. (No. 14). Cloth; 5½ × 9 ins.; pp. xlii. + 387; two folding maps.

ELEVATOR SERVICE.—By Reginald Pelham Bolton, M. Am. Soc. M. E., Author of "Motive Powers and Their Practical Selection." Operating Conditions and Proportions, with Diagrams, Formulas, and Tables for Passenger Travel, Schedule and Express Operation, with the Relation of the Elevators to the Building, and Proportions and Loads of Cars. New York: The author (527 Fifth Ave.). Cloth; 7½ × 11 ins.; pp. 69; folding and other diagrams. $5, net.

FAIRMOUNT PARK ART ASSOCIATION.—Report of the Commission (Paul P. Cret, Horace Trumbauer, C. C. Zantzinger) Employed by the Association to Study the Entrance of the Philadelphia Parkway into Fairmount Park, as Presented at the 26th Annual Meeting of the Association, Dec. 12, 1907. Also the Address on "Architectural Development of Cities" Delivered by Ralph Adams Cram on the Same Occasion. Philadelphia, Pa.: The Association. Paper; 9 × 12 ins.; pp. 27; five illustrations in the text and one large folding plan.

GAS POWER.—A Study of the Evolution of Gas Power, the Design and Construction of Large Gas Engines in Europe, the Application of Gas Power to Various Industries and the Rational Utilization of Low Grade Fuels. By F. E. Junge, M. A., C. E., M. El, Member Verein Deutscher Ingenieure. New York and London: Hill Publishing Co. Cloth; 6 × 9¼ ins.; pp. 548; 8 plates and 159 text illustrations. $5.

MODERN PIGMENTS AND THEIR VEHICLES.—Their Properties and Uses Considered Mainly from the Practical Side, and How to Make Tints from Them. By Frederick Maire, Author of the "Modern Wood Finisher," etc. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 4¾ × 7½ ins.; pp. 206. $2.

PRACTICAL STEAM AND HOT WATER HEATING AND VENTILATION.—A Modern Practical Work on Steam and Hot Water Heating and Ventilation, with Descriptions and Data of All Materials and Appliances Used in the Construction of Such Apparatus; Rules, Tables, etc. By Alfred G. King, Author of "Steam and Hot Water Heating Charts," etc. New York: The Norman W. Henley Publishing Co. Cloth; 6 × 9¼ ins.; pp. 402; 304 illustrations in the text and 66 tables. $3.

RECEIPTS AND EXPENDITURES OF ORDINARY REVENUE.—With Appendix Including Analyses of Extraordinary Receipts and Expenditures. 1902-1906. Special Publications No. 14, Statistics Department, City of Boston. Boston, Mass.: Pub. Doc. Paper; 9 × 11¼ ins.; pp. 167; one folding table.

STATIONARY STEAM ENGINES.—Illustrated with Numerous Examples from Actual Practice. Edited by William H. Fowler, M. Inst. C. E., M. Inst. M. E., etc. Manchester, England: The Scientific Publishing Co. Cloth; 7¼ × 10 ins.; pp. 299; 326 illustrations in the text. 12s., 6d., net; American price, $5.

THE GAS-ENGINE.—A Treatise on the Internal-Combustion Engine Using Gas, Gasoline, Kerosene, Alcohol, or Other Hydrocarbon as Source of Energy. By Frederick Remsen Hutton, E. M., Ph. D., Sc. D., Emeritus Professor of Mechanical Engineering in Columbia University. Third Edition, revised. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¾ × 9 ins.; pp. 562; 250 illustrations in the text. $5.

WATER RESOURCES OF THE EAST ST. LOUIS DISTRICT.—By Isaiah Bowman, Assisted by Chester Albert Reeds. Bulletin No. 5, Illinois State Geological Survey. H. Foster Bain, Director. Urbana, Ill.; University of Illinois. Paper; 5½ × 8¾ ins.; pp. 128; 4 plates and 11 text illustrations.

WATER-SUPPLY AND IRRIGATION PAPERS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.

No. 205: Surface Water Supply of Ohio and Lower Eastern Mississippi River Drainages, 1906. M. R. Hall, N. C. Grover, and A. H. Horton, District Hydrographers. Pp. 123; three plates and two text figures.

No. 207: Surface Water Supply of Upper Mississippi River and Hudson Bay Drainages, 1906. A. H. Horton and Robert Follansbee, District Hydrographers. Pp. 94; four plates and two text figures.

No. 209: Surface Water Supply of Lower Western Mississippi River Drainage, 1906. R. I. Meeker and J. M. Giles, District Hydrographers. Pp. 79; two plates and two text figures.

No. 210: Surface Water Supply of Western Gulf of Mexico and Rio Grande Drainages, 1906. T. U. Taylor and W. A. Lamb, District Hydrographers. Pp. 114; two plates and two text figures.

No. 216: Geology and Water Resources of the Republican River Valley and Adjacent Areas, Nebraska. By G. E. Condra. Pp. 71; 13 plates and 3 text figures.

WATERWAYS DEVELOPMENT.—Also "Rochester, Pittsburg and New Orleans Waterway," and "Mechanical Lift Locks." The Middle Line from Lake Ontario to Gulf of Mexico. (Addresses by John A. C. Wright, J. T. McClintock, and Wm. R. Davis.) Proceedings of Rochester Chamber of Commerce at the Regular Meeting, Dec. 2, 1907. (S. R. Clarke, Secy.) Paper; 6 × 9 ins.; pp. 23; one map.

WHOLESALE LUMBER PRICES, 1886-1908.—Washington, D. C.: Forest Service, U. S. Department of Agriculture. Single sheet, 17 × 13 ins.; tables, only.

WIRELESS TELEPHONY.—In Theory and Practice. By Ernst Ruhmer. Translated from the German by James Erskine-Murray, D. Sc., M. Inst. E. E. With an Appendix by the Translator. New York: D. Van Nostrand Co. London, England: Crosby Lockwood & Son. Cloth; 5½ × 8¾ ins.; pp. 224; 145 illustrations in the text. $3.50, net.

WOOD DISTILLATION.—By W. C. Geer, Expert. Circular 114, Forest Service, U. S. Department of Agriculture. Gifford Pinchot, Forester. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.; pp. 8.

YEAR BOOK OF THE ILLINOIS STATE GEOLOGICAL SURVEY.—By H. Foster Bain, Director. Springfield, Ill.: Pub. Doc. Cloth; 6 × 8¾ ins.; pp. 260; illustrated.

POLLUTION OF NEW YORK HARBOR AS A MENACE TO HEALTH BY THE DISSEMINATION OF INTESTINAL DISEASES THROUGH THE AGENCY OF THE COMMON HOUSE FLY.—A Report by Daniel D. Jackson, S. B., to the Committee on Pollution of the Merchants' Association of New York. New York: The Merchants' Association. Stiff paper; 8 × 11 ins.; pp. 22; folding and other plates.

This unique study shows the desirability of a general cleaning up of the water front of New York City, including the extension of sewer outlets to points beyond and beneath the low water line. It also increases and enforces our knowledge of the fact that flies and exposed filth combine to spread intestinal diseases. But the author seems to have gone altogether too far in the local application of the fly theory to conditions in New York. His maps show, without question, numerous cases of typhoid and other intestinal diseases near the water front, and relatively few cases near the center of Manhattan Island, but the maps fail to show the density of population. It is evident to anyone at all acquainted with Manhattan Borough that some, at least, of the portions of the map which are blackest with dots indicating typhoid cases have the densest population while some of the portions with few or no dots have little or no population. We would suggest for any further study of this general character that in place of a map, diagrams be used, showing, as nearly as may, density of population and number of cases of typhoid fever along lines drawn from the East River to the North River.

INVESTIGATIONS ON THE PURIFICATION OF BOSTON SEWAGE IN SEPTIC TANKS AND TRICKLING FILTERS.—(1905-1907.) By C.-E. A. Winslow and Earle B. Phelps. Contribution from the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology. (Reprinted from the Technology Quarterly, Vol. XX., No. 4, December, 1907.) Paper; 7 × 10¼ ins.; pp. 387 to 452; 19 illustrations, mostly in the text.

Extended extracts from advanced proofs of this valuable paper were published in Engineering News of Jan. 9, 1908.

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